PROCEEDINGS
OF THE
AMERICAN
WELDING SOCIETY

Published by the American Welding Society
33 West Thirty-ninth Street, New York
American Welding Society

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The American Welding Society

The American Welding Society is organized to provide united and co-operative action in extending the knowledge of the art of welding and its field of industrial application. The field for further application of welding is enormous, and progress in it is being delayed only by incomplete knowledge and by the confusing and opposing claims of competing interests.

The Society acts as a clearing house for information. Through papers and monthly meetings of local sections of the Society an opportunity is created for the individual manufacturer, engineer, plant superintendent, foreman, operator, etc., to contribute his own knowledge in welding and at the same time receive the benefit of the combined knowledge and experience of all other members of the Society. Special publications in addition to the regular monthly proceedings are issued from time to time giving results of researches, standardization work and other information of value to the members.

CLASSES OF MEMBERSHIP

Extracts From By-Laws

ARTICLE I.

Section 1. Individuals having received the approval of a majority of the Membership Committee shall become members of this Society upon the payment of dues, except in the case of honorary members who shall be elected by unanimous vote of the full Board of Directors.

Section 2. Membership shall be divided into five classes:

Class A. Sustaining members, being individuals or individuals delegated by corporations, firms, partnerships, etc., interested in the science and art of welding, with full rights of membership.

Annual dues ............... $100.00

Class B. Members, being individuals interested in the science and art of welding, with full rights of membership.

Engineers or individuals competent by experience or training to plan or direct welding operations are eligible to this class.

Annual dues ............... $20.00

Class C. Associate members with right to vote but not to hold office, except in Sections as may be provided for by the By-Laws of the Sections. Supervising welders, inspectors and skilled operators, with three or more years' practical experience in welding are also eligible to this class.

Annual dues ............... $10.00

Class D. Operating members, who are welders or cutters by occupation, without the right to vote or hold office except in Sections as may be provided for by the By-Laws of the Sections.

Annual dues ............... $5.00

Write to the Secretary for a membership blank.
OUR OWN PROCEEDINGS

We present herewith the first number of our own proceedings. An attempt was made in October, 1919, by the Society to publish a Journal and was discontinued after the first issue because of the expense. There followed a short period of five months during which we had no official organ.

In April, 1920, arrangements were made with the Welding Engineer whereby part of each number of this monthly journal was given over to the proceedings of the American Welding Society. For a time this was the only possible arrangement. There was some objection because it was not always possible to separate the proceedings of the Society from other printed matter appearing in the Welding Engineer and the binding of the proceedings for permanent record proved to be impossible. The opponents to this plan argued that the proceedings of the Society should not ordinarily be available to non-members. Moreover, it was impossible to include news items of the Society, local sections, committees, or of the American Bureau of Welding and of the industry. Moreover, certain sections should be devoted to editorials, employment service, bibliography of current welding literature, names of new members, etc. An attempt was made to fulfill these requirements in the first issue. However, monthly publication of our own proceedings will be made possible only through the increase of membership and the payment of dues by delinquent members.

In closing we wish to express our thanks to the Welding Engineer and its editor, Mr. L. B. Mackenzie, one of our most loyal members, who co-operated by offering the use of the Welding Engineer as our official organ until the present form of proceedings was made possible. Copies of each issue of our proceedings will be mailed to each paid-up member.

NEW SECTIONS ORGANIZED IN THE WEST

Mr. C. A. McCune, Chairman of Membership Committee, who has recently returned from a business trip to the Pacific Coast, reports that the West is keenly interested in the American Welding Society. The welding applications of the West and Pacific Coast differ from those of the East in relation to the industries but naturally the actual performance of the work, the necessity for properly training operators, establishing standard methods of welding procedure, standard methods of testing, etc., is the same all over the country. National co-operation is needed if the Society is to accomplish all that is expected of it.

Preliminary meetings were held in
Denver, Portland, San Francisco and Los Angeles and Local Sections of the Society will be organized shortly in each of these cities.

If the enthusiasm displayed at these meetings is an indication of the real interest in welding and the Society, we can expect to shortly have a Western membership which will rival in numbers that of the East.

**OBLIGATIONS***

The American Welding Society is an association of men who have banded together in the effort to achieve through co-operation the extension of the knowledge of the art of welding and its field of industrial application—a purpose which cannot be accomplished by individuals or by a single corporation. Each of you joined because the Society is striving to do something which you want done. You were received as a member because you thus expressed a desire to help and as a member you stand voluntarily committed to contribute your active aid. The act of joining in no way fulfilled your obligation. No member can conscientiously sit back and wait for the Secretary or the headquarters staff to do the work.

Some of the things you can do:

1. See that your dues are paid promptly. The entire revenue of the American Welding Society is expended to defray current expenses. Budgets are made out on the assumption that your dues will be forthcoming promptly. Every delinquent member means extra work to an overburdened staff. The loss of dues means that some desirable activity must be curtailed or abandoned.

2. Get new members. Every new member means an additional push to a united effort. The extra money allows greater activities and greater returns to the members.

3. Attend meetings. If you stay away from the meetings of your Local Section you are not fulfilling your obligations. It may be that your discussion of a paper would have helped—would have thrown a new light on a difficult problem. Perhaps, too, you missed hearing or learning something that would have been to your advantage.

4. Contribute toward the success of the Society. Tell your friends about it! If you have worked up or discovered something new or collected some interesting data write an article about it and contribute it to the Society. You have ideas how to improve these Proceedings or how to help the Society in other ways. Write and tell us about it.

**THE DRIVE IS ON!**

Beginning early in February and covering a period of ten days the American Welding Society is planning to conduct a national drive to increase its membership. This drive will be known as a GET A MEMBER DRIVE. On or before February 1st every member of the Society will receive from their Section Chairman a letter requesting that he consider himself a membership committee. The object of the drive is that each member get another member of equal rank.

It is seldom that your Society appeals to each individual member for definite co-operation in any undertaking, probably because it is blessed with a great number of self-sacrificing individuals who devote much time and go to considerable personal expense for it. We know that you will co-operate and suggest that you look over your list of friends and business acquaintances and find at least one of them whom you can get to become a member of the Society. Increased membership means direct returns to you and every member of the Society.

**WHY YOUR FRIEND SHOULD BECOME A MEMBER OF THE AMERICAN WELDING SOCIETY**

1. The American Welding Society is a national organization representing the highest standards of the welding industry.

2. The work of its various commit-
tees has been an important and valuable factor in developing, stabilizing, and standardizing the entire welding industry.

3. Membership will help increase his knowledge of welding, help him to improve his application of the art.

4. He is offered many opportunities to make personal contact with the leaders of the industry.

5. He will profit by the experience of the finest trained minds in the welding industry—experience which will save him money.

6. He will receive a monthly publication giving reliable data on the development of the art.

7. By supporting the Society he will help raise the standard of welding efficiency and help to increase the number of efficient welders.

8. Section meetings and publications of the Society offer a medium open to members for the presentation and discussion of their views on welding topics.

9. His support will help the Society to counteract adverse legislation and other activities which may not only retard progress of welding but also affect his business.

10. Increased membership will help us carry out new activities, will help us maintain departments, which at the present time our limited finances will not permit, such as Employment Bureau, Library Facilities, Standardization work, etc.

The industry that supports you deserves your support. Don't put off getting your member to the last day. Do it now! We cannot even continue the monthly publication of these proceedings unless we get new members.

BUREAU PAMPHLET

The American Bureau of Welding (Research Department of the Society) recently published a twenty-four-page pamphlet setting forth the progress made by its eleven research committees. The pamphlet also contains brief accounts of the National Research Council and its relation to the Bureau, the welding opportunity and the American Welding Society, and the needs for research and standardization. A few copies are still available and may be obtained by applying to the secretary of the Society.

DISCUSSION OF TECHNICAL PAPERS

The Society invites discussion of the technical papers and items printed in its proceedings. If you can supplement the information given in some paper, will you kindly send it in to the secretary and it will be published in an early issue of the Proceedings under "Discussion of Papers."

NOTICE TO MEMBERS

Inasmuch as we are now publishing our own proceedings, the "Welding Engineer" will no longer be sent free of charge to the members of the Society. You may obtain copies, however, by subscribing for the "Welding Engineer." Subscriptions should be sent directly to L. B. Mackenzie, Welding Engineer Publishing Co., 608 South Dearborn Street, Chicago. We cannot urge our membership too strongly to continue their subscriptions, as we regard it as the most important trade paper published on the general subject of welding.

EMBLEM

All members of the Society are privileged to wear the Society emblem. Emblems may be obtained in two styles from the Secretary's office. Price, gold-filled 75c. 14 K gold $5.00.
RESEARCH ACTIVITIES

CAST IRON WELDING

Ways of successfully welding cast iron have been known and employed for a good many years. These ways have, however, been attended by disadvantage as regards convenience and cost. The characteristics of the weld in several respects notably as regards strength and machinability have left much to be desired.

The Electric-Arc, Gas and Thermit Welding Research Committees of the American Bureau of Welding recognizing the need of improvement and standardization of methods now employed in the welding of cast iron are giving this subject careful attention.

A small sub-committee of the Electric Arc Welding Committee, under the chairmanship of W. H. Namack of the Davison & Namack Foundries has been devoting its activities to the preparation of a critical summary on the present state of the art. This summary will set forth the recognized procedure now successfully used in the electric arc welding of cast iron. A program of research will be outlined on those problems needing investigation and where authentic information is lacking. The summary will be published in an early issue of the Proceedings and will be followed by summaries on Gas and Thermit Welding of cast iron prepared under the supervision of S. W. Miller and J. H. Deppeler respectively.

STANDARDIZATION OF THE RATING OF ARC WELDING APPARATUS

Everyone connected with the welding industry has long felt the need of some agreement as to what shall constitute a one-arc machine. At the present time there is no agreement among the manufacturers of arc welding apparatus as to method of rating. A prospective purchaser is bewildered by the confusing claims of the special merits of the different machines on the market and unless he has had previous experience in welding he has no basis for judging the real merits of the several types.

H. M. Hobart, chairman of the Electric Arc Welding Committee and also member of the Standards Committee of the American Institute of Electrical Engineers, recognizing the need of standardization in this field, appointed a small sub-committee under the chairmanship of W. Spraragen to draw up preliminary standards. The first draft has been completed and submitted to the A. I. E. E. Standards Committee. The rules have been possible through an agreement by the manufacturers that the continuous loading for one hour by means of a suitable resistance at full load current gives the same temperature rise as an all-day operation in service by manual manipulation of the arc with the same current. Other valuable information which will be of assistance to the purchaser is contained in these rules. The sub-committee will cooperate with the A. I. E. E. Standards Committee in completing this work and in fact have had from the outset the valuable guidance of F. M. Farmer, Chief Engineer of the Electrical Testing Laboratories, who is thoroughly familiar with the policies of the Standards Committee of the Institute.

BULLETIN NO. 1

Standards for Testing Welds

Standardization of the procedure in making a test of any kind is obviously necessary before results obtained by different observers can be compared.

The chief difference between testing a specimen of steel that includes a welded joint and testing an ordinary specimen is the non-homogeneity of the welded specimen. The welded specimen has at its center a section composed of material that usually has physical, chemical and metallurgical characteristics distinctly different from the adjoining metal. Furthermore, the section of the added metal is more or less irregular in shape and variable in size. Consequently the procedure prescribed for testing ordinary specimens is not applicable to specimens containing welded points.

Differences in details of procedure
have caused widely divergent results and comparisons are frequently impossible, consequently the usefulness of much of the research work as recorded is restricted and in many cases the statement of results are actually misleading.

The committee appointed to deal with this subject has drawn up specifications for the standard tests of welds, comprising—

(a) Shop Standard: A simple standard test for such purposes as checking the work of a welder, testing a new lot of welding wire, and testing the effect of some change in conditions.

(b) Commercial Standard: For cases where more than one kind of test should be made but where the circumstances do not justify a complete investigation.

(c) Research Standard: When a complete investigation of a weld is to be made for research or other purposes, all tests and examinations are made which will contribute any information in regard to the characteristics of the weld.

These specifications are available in bulletin form. Price per copy—Members, 25 cents; non-members, 50 cents.

BULLETIN NO. 2
Welding Wire Specifications and Folios

Several years ago the notion prevailed that almost any fence wire was good enough for welding, and although good results were sometimes obtained from the use of fence wire, it is now recognized that most careful attention must be given to the physical as well as to the chemical characteristics of welding wire if good results are to be assured.

During the greater part of the past year and a half the Welding Wire Specifications Committee has been actively engaged in collecting data as to the chemical analysis of welding wire used for both gas and electric welding in railroads, shipyards and other places and the service results obtained from the use of such wire. Specifications based upon this information have been drawn up and are now available in bulletin form. Price per copy—Members, 25 cents; non-members, 50 cents.

SECTION NEWS

CHICAGO SECTION MAKES A GOOD START

Renewed interest has marked the activities of the Chicago Section during the past few months. Meetings have been well attended, and the attitude of those interested in the autogenous welding processes indicates a banner year for this section.

At the November meeting officers and directors were elected for the coming year and, under the guidance of the new chairman, E. Wanamaker, the affairs of the Section have made rapid headway.

The December meeting of the Section was held on December 2, with an attendance of 65 local enthusiasts. The meeting was addressed by H. R. Pennington, Welding Supervisor, Rock Island Railroad, his topic being, "The Welding of Manganese Steel." A general discussion followed which was indicative of the very general interest in this subject. Copies of Mr. Pennington's paper had been printed in advance and this arrangement was of great assistance in promoting general discussion.

The January meeting was held on January 6 with a record attendance of 85 men interested in all branches of the welding art. A feature of this meeting was the attendance of 30 students of gas welding at the Greer and Rabé schools, together with their instructors. This meeting was addressed by M. Keith Dunham, author of "Automobile Welding with the Oxy-Acetylene Flame," who spoke on the cost and upkeep of gas welding equipment.

A special report by Mr. Kremer, Sales Manager of the Vilters Mfg.
Co. of Milwaukee, who was unable to be present, was received too late to present, but is being sent out to all who attended.

A helpful factor in meetings of the Chicago Section is the dinner held each month preceding the open meeting. Seventeen were present at the “get-together” preceding the January meeting.

Mention should also be made of the helpful co-operation of C. T. Nelson of the General Boilers Company, Waukegan, Ill., who has made special arrangements for welders in his establishment to attend meetings of the Chicago Section. When more companies proceed along such lines this organization will have gone a step farther in fulfilling its function in the dissemination of knowledge in welding.

Meetings of the Chicago Section are held at 8 p.m. the first Friday in each month in the rooms of the Western Society of Engineers, in the Monadnock Block, Dearborn and Van Buren streets. A cordial invitation to attend is extended to all interested in welding.

OFFICERS OF CHICAGO SECTION
Chairman—E. Wanamaker, C. R. I. & P. Ry.
Vice-Chairman—E. G. Luening, Consulting Engineer
Secretary-Treasurer—H. W. Cook, Acetylene Journal.


REPORTS FROM CLEVELAND
Cleveland reports that their membership is gaining and at present is forty-one. Prospects are brighter as the industries in the Section are more active than they have been for the past ten months.

The December meeting was held on the eighth of the month at the Cleveland Engineering Society and was addressed by G. V. Carter, Consulting Engineer of the Linde Air Products Company. Mr. Carter spoke on the “Dependability of Cast Iron Welding.”

The job shop welder came in for his share of attention, as the January meeting was largely devoted to his interests. This meeting proved to be one of the most successful since the organization of the Section. Mr. Boom of the Boom Boiler & Welding Co., gave his explanation of how his firm figured the cost of a job given by C. L. Bennet. Mr. Haig of the Aetna Welding Co. gave his version of cost on the same problem. Discussion became general and many illuminating facts were brought up; also considerable good-natured argument. In fact, so diverse were opinions on how to weld a hypothetical pulley wheel that it was agreed to bring several cast-iron pulley wheels rim broken to the next job shop welders meeting and the champions of the various methods promise to defend their ideas by actual demonstration.

Hugh H. Dyer discussed briefly the subject “Does It Pay to Knock Your Competitor?” He cited how a friend of his, a manufacturer, called in three job shop men to bid on a repair job. In the course of the conversation the welders bidding were told that the other two men were bidding also. In each instance the welder based his selling talk in the main on how uncertain his competitors’ workmanship were and that the only way to assure a perfect job would be to give him the job. Naturally, the manufacturer resented these poor business tactics. So in discussing the matter with Mr. Dyer this man said: “Now, either welding as an industry isn’t worth its salt or every one of those three welders were liars. I’m going to buy a new casting, and I’m through with welders and welding.”

The inference is obvious. One welder can make or lose a friend for the welding industry. It’s a good deal
better to lose a customer to a competitor than to bring grief to the industry.

Mr. Eberhardt of the Eberhardt Welding Co. was congratulated on his attendance. His men were out in force with him and helped swell attendance.

Special Notice

All members of Cleveland Section are invited to use the manual on arc welding compiled by the Chicago, Rock Island and Pacific R. R. Co. at a cost of $50,000. The research work alone represents the work of their engineering department over a period of four years.

This copy, loaned to the Section, may be read at the office of the secretary, fourth floor, Euclid Arcade Building, and arrangements may be made for its loan to members for a period of not exceeding two days.

METROPOLITAN SECTION HOLDS REGULAR MONTHLY MEETINGS

The September meeting of the Metropolitan Section proved to be one of the most interesting held this year. E. Wanamaker of the Chicago, Rock Island & Pacific Railroad delivered a paper on the "Practical Applications of the Electric Arc Welding Process." The paper dealt with the three prime requisites of electric arc welding.

1. Skill necessary in applying the weld or designing parts to be welded.
2. Requirements of equipment.
3. Quality of material to be welded.

Mr. Wanamaker's paper was published in the November issue of the "Welding Engineer."

The October meeting of the Section was devoted to a discussion of the paper by F. B. Webster on the subject of "Broadening the Use of Welding in Shipbuilding." Mr. Webster's paper was distributed in advance to all members of the Society by the Meetings and Papers Committee.

The November meeting was devoted to a discussion by Messrs. W. A. Kretz of the John A. Roebling's Sons Co., and J. H. Deppeler of the Metal & Thermit Corporation; of a paper by Professor Slocum on "Residual Stresses in Joints and Structures." At this meeting also S. Diggle of the Homogeneous Construction Co. gave an interesting discussion of a paper by A. M. Blenus on "Welded Structures."

The December meeting was held in joint session with the American Society of Safety Engineers. Two papers were delivered on the general subject of "Development of Safety in Oxy-acetylene Cutting and Welding." The first paper was presented by F. J. Napolitan of the Research Laboratory of the Davis-Bournonville Co., on "Safety Engineering as Applied to Oxy-Acetylene Cutting and Welding."

This paper was followed by one on "Development of Protection as It Parallelled the Development of the Oxy-Acetylene Process," by J. I. Banash of Chicago. Mr. Banash's paper is printed in this issue and the one by F. J. Napolitan will be published in the next number.

The January meeting of the Section will be given over to discussions by practical welders. This meeting will be held on Jan. 17 in the Engineering Societies Building.

NORTHERN NEW YORK SECTION HOLDS INTERESTING MEETING

The November meeting of the Northern New York Section was held Nov. 15 at Edison Club Hall, Schenectady. T. W. Jenkins, Development Engineer of the American Rolling Mills Co., delivered an address on the history and production methods used in the production of Armco iron and welding rods. Ingot iron is obtained in commercial quantities and at a cost which is competitive by the use of specially pure raw materials and careful attention and testing throughout the manufacture of the iron. Originally this product was intended as a rust-resisting metal, but it has since developed a number of desirable characteristics, so that its field has widened enormously.

The lecture was accompanied by motion pictures of the various stages of production of this metal, and the audience of 180 was thus enabled to make a trip in one hour that would ordinarily take a week or more if one were fortunate enough to have the opportunity to visit a steel plant.
JANUARY MEETING OF THE
PHILADELPHIA SECTION

A program of more than ordinary interest has been prepared for the January meeting of the Philadelphia Section. The subject for general discussion will be "Pipe Welding and Welded Pipe."

Three very excellent papers have been selected for the presentation of above subject in its respective phases, viz., "Fusion Welding as Applied to Wrought Pipe Joints," by F. N. Speller, Chief Metallurgical Engineer, National Tube Company, Pittsburgh; "Production Welding on Steel Tubing and Fittings," by R. D. Malm, Superintendent Standard Steel Parts Company, Cleveland; and "Welding a 2200 Foot High Pressure Underground Steam Line in Congested City Streets," by E. L. Hopping, Mechanical Engineer, Philadelphia Electric Company, and M. B. Klutz, Manager National Electric Welding Company, also of Philadelphia.

After the first presentation of papers and showing of lantern slides and moving pictures illustrating their essential features the discussion will be opened by three well known engineers who have specialized in pipe welding. Following this the program provides for a general discussion of the subject by all present.

In view of the importance of the installation described in Mr. Hopping's paper and the introduction of hitherto unpublished data supplied by Messrs. Speller and Malm the presentation of the foregoing papers is sure to justify a very large attendance.

In accordance with their usual custom the Executive Committee of the Philadelphia Section will entertain the speakers of the evening and other invited guests at dinner at the Engineers Club. The Philadelphia Section dinners have already become quite an institution.

PITTSBURGH SECTION
ACTIVITIES

A very interesting meeting of the Pittsburgh Section was held on November 29 at the Monongahela House, Pittsburgh, with an attendance of forty people. A. R. Allard of the Westinghouse Electric & Manufacturing Co. presented a paper upon the subject of "Welding Cast Iron with Electric Arc," illustrated by pictures. After the lecture the paper was discussed by a number of welders present.

Note.—Mr. Allard's paper is printed in this issue of the Proceedings.

NEW MEMBERS FOR MONTHS OF JULY, AUGUST, SEPTEMBER, OCTOBER, NOVEMBER AND DECEMBER

NEW YORK

Eric Ewertz, General Manager of Moore Plant, Bethlehem Shipbuilding Corp. A
W. M. Corse, General Manager, Monell Metal Production Co. B
Paul Keese, Welding Promotion Company B
P. B. Corkum, Electric Welder, 30 Broadway, Jersey City, N. J. D
L. J. Cullen, Electric Welder, Staten Island Shipbuilding Co. D
G. J. Davies, Electric Welder, Delaware, Lackawanna & Western R. R. D

PHILADELPHIA

J. A. Delarnelle, Electric Welder, 71 West 108th Street, N. Y. D
Eugene Donohue, Electric Welder, U. S. Navy Yard, Brooklyn, N. Y. D
Michael J. Hart, Electric Welder, U. S. Navy Yard, Brooklyn, N. Y. D
LaVerne Loneland, Oxy-Acetylene Welder, Linden, N. J. D
W. C. Schrader, Foreman, American Motor Body Co. B
I. D. Shipper, J. G Brill Co B
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<td>C</td>
<td>C. T. Hansem</td>
<td>Engineer, American Motor Body Co.</td>
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<td>C</td>
<td>G. L. Wiley</td>
<td>Instructor, Cosden &amp; Co.</td>
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<tr>
<td>C</td>
<td>W. C. Hoffman</td>
<td>2406 So. 8th St.</td>
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<td>H. G. Kellgren</td>
<td>Camden, N. J.</td>
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<td>C</td>
<td>Ernest Krieger</td>
<td>Acetylene and Electric Welder, Wm Cramp &amp; Sons</td>
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<td>C</td>
<td>J. R. Lamar</td>
<td>Acetylene Welder, Newport News Shipbuilding &amp; D. D. Co.</td>
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<tr>
<td>C</td>
<td>Wm. Leslie</td>
<td>Special Apprentice, Baldwin Locomotive Works</td>
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<tr>
<td>C</td>
<td>Adam Robb</td>
<td>Gas Welder, 2821 N. Constitution Rd., Fairview, N. J.</td>
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<tr>
<td>C</td>
<td>Henry Boldejarz</td>
<td>Burner, Pittsburgh Steel Co.</td>
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- M. Gordon, B. M. Welder, New York Central Railroad

**SOCIETY (not in sections)**

- Mototern Karamiishi, Gen. Mgr., Mitsubishi Dock Yard & Engine Works, Kobe, Japan
- George Davies, Welder, Central Welding Works, Manchester, England
- G. H. Wion, Asst. Signal Engineer, Victorian Railways, Melbourne, Australia
EMPLOYMENT SERVICE BULLETIN

To meet the demand of its members, the American Welding Society expects to maintain an Employment Service Bulletin. This service is particularly needed in the present business depression and the coming readjustment. The bulletin will be divided into two sections—POSITIONS VACANT and SERVICES AVAILABLE. No charge will be made either to the available engineer, foreman or welder, or to the organization seeking welding talent. The number of opportunities for employment of which the Society has knowledge does not at present equal the number of men whose services are available. The cooperation of members of the Society, industrial establishments and others needing the services of men trained in the various branches of welding is earnestly desired. The fact that an applicant for a particular position reads the Proceedings of the American Welding Society shows an honest effort on his part to keep abreast of the latest advancements in his chosen field. The location, necessary qualifications for each position and the approximate salary, if possible, should be stated in each case.

Opportunities.—The Society is glad to learn of desirable opportunities from responsible sources, announcements of which will be published without charge in the bulletin.

Services Available.—Under this heading brief announcements (not more than seventy-five words in length) will be published without charge to members. Announcements will not be repeated except upon request received after an interval of three months; during this period names and records will remain in the office reference files.

Note.—Copy for publication in the BULLETIN should reach the Society's office not later than the Thirtieth of the month if publication in the following issue is desired. All replies should be addressed to the number indicated in each case and mailed to Society Headquarters.

SERVICES AVAILABLE

A-2. Welding Supervisor would like to become connected with reliable company in this capacity. Have had eleven years' experience as welder and supervisor on all kinds of repairing and new work in shipyards and factories and can engineer and direct any kind of welding job—acetylene, electric or thermit. Also operate acetylene and oxy-hydrogen generating and compressing plants. I am a boiler maker and shipbuilder of 23 years' experience and have been in my present position for seven years.

POSITIONS OPEN

V-2. Salesmen.—Two openings with large corporation for Salesmen of electric arc welders and welding repair jobs for the New York district. Appointments for interviews will be made only after applicant has written letter giving full particulars including experience in welding salesmanship, age, etc.
EVERYONE familiar with the merits, as well as the limitations, of applying the electric arc welding process to cast iron and obtaining good welds recognizes the need of a better understanding of the methods of applying this process to this class of work.

Certain fundamental facts concerning the metal, its characteristics, constituents and their relation to welding of cast iron, must be thoroughly understood in successfully developing, supervising and applying electric welding to cast iron if satisfactory welds are to be obtained.

The discussion following points out the most important of these points in a clear, non-technical manner so that one need not be versed in metallography to comprehend and grasp the discussion and conclusions.

Cast iron which comes to the attention of the shop man is made of melting pig-iron and pouring it into molds which form it while molten into the desired shape or casting. Of all commercial products of iron, cast iron is the least removed from the original ore. It retains more nearly the physical and chemical characteristics of the ore and is the product of the first refining process. It requires extensive processes to refine the ore to the stage of commercial steel. Chemically pure iron or ferrite is the highest stage of refinement and is only a laboratory product. It contains no impurities, such as carbon, silicon, sulphur, manganese or phosphorus. Commercial cast iron contains all these impurities in varying amounts, as well as other less important ones. The effect of these impurities on the cast iron, and the physical characteristics, due to their presence, must be carefully studied by the welding engineer.

Carbon is present in cast iron in amounts varying from 2 per cent upward, an average sample containing approximately 3 per cent by weight. The relation of carbon content of cast iron to welding conditions is probably better understood when measured by bulk rather than by weight. The quantity, as stated in any analysis, is by weight and may be converted into an approximate measurement of bulk by multiplying by $2\frac{1}{4}$. About 7 per cent of the bulk of ordinary cast iron is made up of carbon.

Carbon, which is ordinarily considered as infusible, has the property of readily dissolving in molten metal at about 2300 deg.
Fahr. when found in cast iron containing 3 per cent carbon. At this temperature all of the carbon present has combined with the molten metal to form a mixture of carbon and iron. We now say that the carbon is in the combined form, or that we have a mixture known as iron carbide. In order to retain the carbon and iron in the combined state it is only necessary to cause the molten mass to solidify or chill instantly by bringing it into contact with water, a cold mold, or an iron chill, either of which will conduct the heat from the mass with varying degrees of rapidity depending on conditions.

The retaining of the relation between the two substances is dependent upon the speed with which the heat is removed from the mass. When a specimen of metal cooled in a chill is examined, a substance quite different from cast iron and resembling more closely a piece of steel is found. A fracture shows a silvery, fine-grained metal of great strength, but extremely hard and brittle, the greatest hardness being accompanied by maximum brittleness, and each dependent upon the rapidity of chilling. This material is what is known as chilled cast iron and will require remelting or extensive annealing to effect a change to cast iron. It requires from one to three days and often longer to anneal even small sections of chilled iron.

If, instead of chilling the molten metal, we go to the other extreme and cool it as slowly as possible, it will be found that the carbon has separated from the iron into the flaky state known as graphite. This graphite cast iron represents the softest, though the weakest, state of cast iron and is easily cut or machined. It is noticed when cutting or filing that there is a black dust present which readily soils the hands. This dust is carbon dust from the casting. A sample of this graphitic cast iron shows very closely the proportion which exists in the mixture of carbon and iron.

Between the two extremes of chilled cast iron and graphitic cast iron we have cast iron which is partly graphitic and partly combined carbon. The usual type of these castings contains 0.25 to 1.50 per cent combined carbon and the remainder as graphite or free carbon.

Silicon (0.50 to 3.50 per cent) is found in cast iron and in certain amounts aids the formation of graphitic cast iron, however the addition of silicon beyond certain fixed limits has an effect similar to that of carbon. An example of high silicon cast iron is found in castings of certain electrical apparatus, the iron of which cannot be cut or filed. Silicon raises the melting point of iron. It also volatilizes readily.

Sulphur (less than 0.10 per cent) reduces the fluidity of cast iron and promotes unsoundness except in cases where the molten metal is chilled readily enough to prevent segregation of masses of it.

Phosphorus (up to 1.50 per cent) increases fluidity and brittle-
ness of cast iron. It also retards the absorption of carbon by the molten iron.

Oxygen breaks up the graphite of cast iron.

We have previously considered three grades of cast iron as represented by the state of the carbon: (1) wholly carbide; (2) wholly graphitic; (3) partly combined carbon and partly graphitic or free carbon. Consider now the formation of 1, 2 and 3 in the light of additional knowledge of the other constituents of cast iron.

1—White cast iron (combined) (wholly carbide), which is hard and brittle with a fine-grained structure like steel, may be produced by—
   (A) Quick cooling through and below the point of solidification.
   (B) Presence of much manganese.
   (C) Absence of silicon.

2—Gray cast iron (graphitic), which is soft, easily cut and has a structure of iron interspersed with flakes of graphite or free carbon, is produced by—
   (A) Slow cooling through and below the solidification point.
   (B) Presence of silicon in correct amount.
   (C) Absence of manganese.

3—Cast iron between these two stages is dependent on—
   (A) Rate of cooling.
   (B) Silicon content.
   (C) Manganese content.

Present Arc Welding Methods

Carbon arc welding is probably the oldest, and easiest in point of manipulation, of the arc methods of welding in use on cast iron. It consists of drawing an arc between a carbon pencil and the cast iron part, causing the metal of the casting and the filler rod to become molten at the point of heat application.

Cast iron which melts at 2300 deg. Fahr. and vaporizes at 3300 deg. Fahr. becomes very fluid under the heat of the arc, so that practically the only position in which this method can be used is in welding on a horizontal plane and on metal of sufficient thickness to prevent the intense heat of the arc from melting through. Sometimes a backing of refractory material is built about the work to facilitate the operation of welding.

Various metals have a characteristic known as the critical welding heat, at which point the metal suddenly changes from the plastic to a fluid state and above which the further application of heat for extended periods causes burning of the metal. From the point of critical welding heat, pure iron is more easily welded by the arc methods than any other metal. Welding becomes more difficult
with increasing amounts of carbon until the point of carbon content is reached which produces cast iron.

Cast iron, when held at a red heat for long periods, will deteriorate, causing it to warp and crack, and if held at high temperature will soon decompose to the point of worthlessness.

When the carbon arc method of welding, as described, is used, the metal is quickly brought to a molten state at the surface, and at this heat the carbon of the metal is dissolved in the iron. When the arc heat is removed the cold sections of the casting quickly conduct the heat from the molten section, causing it to chill rapidly with the attendant formation of chilled cast iron (Fig. 1). This is exactly what takes place when pouring molten iron into a chill.

Figure 1—Characteristics of Cast Iron Welded by the Carbon Arc Method. Note the difference in grain structure between the chilled cast iron and the original cast iron. Chilled section is full of gas pockets and cracks, also extremely hard and brittle.

Metallic arc welding is another arc method used quite extensively for certain applications. In this method the arc is drawn between the cast iron and a steel wire electrode, causing the steel wire to melt and be deposited in the section of the cast iron melted by the heat of the arc. The steel thus unites with the cast iron by various degrees of contact, adhesion or amalgamation, as the case may be. Because of the doubtful nature of the union between the two metals it is customary practice to insert steel studs or pins into the cast iron, in order that the steel filler material may unite with them, thus anchoring the steel to the cast iron (Fig. 6). Additional strength, due to whatever fusion is obtained between the original casting and the added metal, and the ease with which close contact is made with irregular surfaces of the casting, thus eliminating the work of preparation, represents the advantages of this method of welding over repairing by bolting a plate to the casting. When this method of welding is used on containers for steam, liquids, etc.,
the seams or edges of the weld can be calked to obtain tight joints. This calking is often necessary on jobs of this class.

In welding cast iron by the metallic arc method, using steel electrodes, the fusion obtained between the two metals is dependent upon the state in which the carbon exists. It is proved by experiment and observed in practice that the closer the carbon approaches the graphitic state the poorer will be the union of metals, while the closer it approaches the combined form the better will be the union of metals. This condition is due to the fact that, as the carbon approaches the graphitic state, there is less continuity of the iron matrix and less cohesion between the iron crystals, due to the laminated structure of the graphite particles. In addition to this, the formation of a layer of residue, of ashy or sandy appearance, between the two metals at the line of fusion prevents the union of the metals. This condition becomes more serious as the carbon approaches the graphitic state and is due to the inability of the molten iron to quickly dissolve the graphite flakes, leaving them exposed to the action of the arc and oxidation.

Figure 2—Characteristics of Cast Iron Welded by the Metallic Arc Method. Note the ashy white appearance of the residue which accumulates between the casting and the deposited metal. This residue prevents the amalgamation of the metals at the line of fusion. The quantity of this residue is dependent upon the physical condition of the cast iron. Note also the gas pockets in the deposited sections.

This layer of residue is formed as the steel matrix of the cast iron becomes molten, and in a molten stage is attracted to and unites with the layer of metal already formed and partly solidified. As this movement of metal takes place, due to molecular attraction, most of the graphite which is in the laminated formation is left
behind, and, being without its supporting matrix, settles to the bottom of the depression left by the movement of the metal. This deposit or layer of graphite, being a good conductor of electricity, concentrates the action of the arc, which partly oxidizes it and packs it into a layer with the dirt and oxide, thus forming the layer of residue which prevents the amalgamation of metals as the line of welding is extended (Fig. 2).

The degree of fusion that can be obtained on any piece of cast iron can be foretold by visual examination of a fracture in the material, or by the application of the carbon arc to a small area of the casting. If the metal becomes fluid when the arc is applied, and spreads over the parent metals to the line of fusion, making a smooth appearance and even contact, instead of receding from the parent metal at the edges of the line of fusion as though they were two foreign substances (Fig. 4), good fusion can be expected.

Upon examination of a weld made by the steel metallic arc process, even though good amalgamation of metals has resulted, numerous small gas pockets are found, particularly in the layer adjacent to the casting. These holes are caused by gas formed
by the application of heat to the layer of graphite, dirt and slag mentioned, and by the volitization of carbon and silicon of the cast iron. There is also a tendency for cast iron to absorb moisture from the air upon being heated. This moisture, upon being gasified, may also cause gas pockets or holes.

With this method of welding there exists between the layers of steel and cast iron a hard area which cannot be cut except by grinding. This area usually consists of a layer of chilled cast iron next to the layer of slag mentioned above, and on the cast iron side of the weld, while on the other side of the layer of slag and adjacent to it there exists a layer of chilled high carbon steel which is formed by the alloying of the molten high carbon metal of the original cast iron with the added steel. This layer of high carbon steel varies in thickness from a very thin layer at the line of slag to the full thickness of the added layer, depending on the character of the cast iron and the depth of penetration secured. It will readily be seen that the deeper the penetration, or depth of cast iron liquified by the application of the heat of the arc, the greater is the amount of molten high carbon metal to unite with the added molten steel. A close inspection of the action of the arc and metals, while the welding is in progress, will show that practically all the molten metal of both the casting and the filler rod unite to form the layer of metal which lies above the line of slag.

Another difficulty in the way of securing satisfactory welds with the metallic arc on some applications is due to the separation and cracking caused by the shrinkage of the molten metal upon solidification. The trouble experienced from this cause is often erroneously attributed to the difference between coefficients of expansion of the two metals.

Contraction and expansion, as everyone who has had experience in welding knows, causes more trouble and failures in the welding of cast iron, by any method, than all other causes combined.

Every physical and chemical change in metal is accompanied by stresses set up within the metal. As these stresses exceed the strength of the metal, it is not hard to understand the warpage and breakage caused by this agent in a metal as weak, rigid and brittle as cast iron. When steel or cast iron is subjected to heat it expands as the heat increases until a point is reached just prior to fusion, when the metal assumes its greatest bulk. On cooling, it again increases to its greatest bulk when passing from the molten to the solid state.

In welding cast iron with the metallic arc, using steel filler material, the difference in contraction between the molten added layer and the casting often causes trouble. The strength of the added steel is much greater than the strength of the cast iron, so that the steel, upon contraction, may pull away from the cast iron (Fig. 5), or in some cases, where good fusion of metals has been
secured, the cast iron will be fractured. The fact that the separation usually takes place at the line of slag or the point of contact of the two metals is due to poor fusion of metals and to the fact that this is the line of creepage or movement between the metals. Even though good fusion of metals has been obtained, the separation will be in the vicinity of this line and on the cast iron side.

The steel metallic process of welding is the only method adaptable for certain applications. Examples of this are found frequently in castings which permit the use of only a limited amount of heat, and in jobs which require welding to be done by overhead manipulation of the arc. This latter is usually prohibitive in other methods on account of the fluidity of molten cast iron.

The following outline covers the general procedure recommended for doing metallic arc welding on cast iron parts.

In preparing a casting for this process care should be taken to remove all scale and sand by chipping or sand blasting the entire surface to which metal will be fused.

A square groove is chipped along the line of the break or crack. The size of this groove depends upon the thickness of the casting and is usually ¼ in., 3⁄8 in. or ½ in. square.

The groove is then filled up by welding until it is flush with the face of the casting.

Locate and set the first stud in the casting as close to the crack as practicable. The location of the stud is determined by the thickness and shape of the casting and the size of the stud. The size and number of studs is dependent upon the volume of added metal required to give the necessary strength. Studs should be long.
Section Y-Z

Figure 6—General Procedure Recommended for Doing Metallic Arc Welding on Cast Iron Parts.
enough to extend through the first layer so that good fusion can be obtained between them and the second layer. The studs should be set as close to the edge of the break and to each other as practicable.

Weld around the first stud with a sufficient number of rows of deposit to reach to the center of the break, as shown at X in Fig. 6. This procedure will determine the area covered by the metal surrounding one stud and will aid in locating the remaining studs.

Locate and set the necessary number of studs to complete the job.

Chip or grind grooves, as shown in Fig. 6. These grooves may be either square or semi-circular, although \( \frac{3}{4} \) in. square grooves are used most frequently. Grooves should be placed between the rows of studs if more than one row is used, and at the outside edge of the weld area.

Figure 6 illustrates the preparation as to grooving and studding, as well as the welding procedure to be followed.

Weld the grooves up flush with the face of the casting.

Weld the first layer around all studs as was done with the first stud. The outside row of the pads of adjacent studs are not united at this time except where they emerge into each other at the outer circumference.

Weld the second layer around all studs (Fig. 6-B), taking care to make the pads cone shape, so as to leave a “V” to be filled when the pads are united.

Weld additional layers if required.

Unite all pads except at the line of the break, taking care to leave this operation until the last in order that the greater part of the shrinkage will have occurred before this union is made. In uniting the pads, when more than one layer of deposited metal has been added, it is best to follow the contour of the pads with additional rows of metal as the welding advances from the bottom of the “V” or base of the cones.

Unite the weld at the break, as shown in Fig. 6.

The operation of welding cast iron by the steel metallic arc method should proceed very slowly, with each addition of metal being very small in order that the heat absorbed by the work may be kept to a minimum.

Drilling at the end of the break or crack is optional and not often required, as the casting should never get warm enough to expand and extend the break.

One of the mistakes made in the application of this method of welding is the practice of building up heavy sections or layers of steel adjacent to the cast iron. When good fusion is obtained the section of steel can be easily kept at one-half that of the cast iron section required to give the necessary strength. It is evident that when the stresses are great enough to warp the steel, it will, in most cases, pull from, warp or break the casting (Fig. 5).

The square groove at the break, when filled by welding, closes up
the break and offers a projection against which the shrinkage of
the added material draws the adjacent sides of the casting, thereby
utilizing as an advantage one of the greatest trouble-giving factors
encountered in cast iron welding. The other grooves are additional
insurance against leakage when welding cylinders or containers for
liquids or vapors. They also give additional strength to the
welding.

The method of "V'ing" out the casting, as shown at "A" (Fig. 6),
was inherited from the practice followed in gas welding and may
be followed when welding sections of casting in which the carbon
is found to be in a condition which will give good fusion between
the casting and the added metal.

The heavy sections of graphitic cast iron usually encountered
should not be "V'ed" out, because the surface of the casting, which
chills quickly when cast, affords a better quality of metal upon
which to weld than is presented as the casting is cut below the
surface. As the cut becomes deeper the amount of graphite present
in the metal increases. Examination of "A," Fig. 6, Section A-B,
will show that no increase of strength is gained by "V'ing" out
in cases where the fusion between the metals is poor.

Figure 6-A also shows another disadvantage to the beveling
method of preparation. There is without question considerable
shrinkage of the steel filler material no matter how carefully the
work is done. Reference to the sketch will show that the shrinkage
draws the bevels of the casting against the beveled boss of the added
section, with the result that the pressure exerted tends to lift the
steel section from the casting, and this, in fact, takes place in
many cases.

The practice, as outlined, will keep the effect of shrinkage strains
to a minimum by affording a procedure which will keep the work
cool, and by affording means of equalizing, balancing and taking
advantage of the stresses which cannot be eliminated. The use
of small wire, as low current as permissible and straight line weld­
ing without weaving or oscillating of the steel electrode will also
assist in keeping the work cool and minimizing the stresses.

The procedure most widely understood has been outlined. The
ideal procedure would result in welds which would have the follow­
ning characteristics:

(1) Good amalgamation of metals.
(2) Prevention of chilled metal at the line of fusion or in the
weld.
(3) Provision for accommodating expansion in the casting.
(4) Elimination of gas pockets and holes.
(5) Same coefficient of expansion between the casting and the
added material.
(6) Deposition of added material which will approximate the
characteristics of the original casting.
Each of the above characteristics can be obtained as follows:

1. Good amalgamation of metals can be obtained by proper filler material and preheating.
2. Chilled metal at the line of fusion or in the weld can be prevented by proper filler material and by preheating.
3. Preheating will also accommodate expansion in the casting.
4. Proper filler material and preheating will eliminate gas pockets and holes.

The proper filler material will result in a deposit which will have the same coefficient of expansion as the casting.

The proper filler material can be obtained which will approximate the characteristics of the original casting.

Although proper filler material and preheating will theoretically give an ideal weld, proper manipulation of the process and a clear understanding of the principles involved are necessary in their practical application.

**Electrode Material**

In good welding practice it is the usual procedure to use filler material having the same characteristics and which will respond to the same treatment, in the same way, as the material of the part being welded. It is also necessary that the expansion and contraction of the parent and added material be the same, and that an amalgamation of metals be secured. It is a logical procedure, then, to use filler material of the same composition as that of the casting or part being welded. There is usually an allowance made in the filler material to take care of losses of the constituents which may be diminished by the welding process.

Electrode material for welding cast iron by the arc process, if governed by the above findings, would consist of cast iron with the following characteristics:

- **High carbon content** to compensate for the loss of carbon due to the application of the intense heat of the arc and to promote the formation of good cast iron.
- **High silicon content** to compensate for losses and to promote the formation of graphitic or free carbon cast iron.
- **Low sulphur content** on account of its detrimental effects.
- **Low manganese content** because of the retarding effect it exercises over the formation of free carbon or graphitic cast iron.
- **Low phosphorus content** on account of the formation of very brittle iron where any appreciable amount is used.

Various compositions of cast iron electrodes have been tried in conjunction with preheating. The standard filler rods made for gas welding give very good results when coated with lime wash, and when the casting can be welded and heated to about 1500 deg. Fahr.

Preheating is necessary in connection with arc welding of cast iron if a weld having the ideal characteristics is to be secured. It accomplishes results as follows:
(1) It relieves residual strains and accommodates expansion and contraction in the casting and between the original and added metal.

(2) It eliminates gas pockets and holes, caused by reasons previously stated, by holding the metal in a plastic or fluid state long enough to enable the gas to escape and oxide or dirt to be released and floated to the surface.

(3) It aids in securing a good amalgamation of metals, particularly when welding graphitic cast iron, by reason of the extension of the period of fluidity which allows the slag to float free, and by reason of shortening the period of time required for the dissolving of the carbon, due to the fact that the preheating has already advanced the process. When castings are preheated the formation of the line of slag is reduced to a minimum.

(4) It permits cooling the metal of both the casting and welded sections as slowly as possible and thus prevents chilling and the attendant formation of chilled iron. Undisturbed cooling promotes the formation of free carbon which is necessary to the production of soft iron. It has been determined that if the cast iron is solidified quickly and then cooled very slowly the carbon, which is in the combined form at the time of setting, will change to the free form as cooling progresses, thus producing a fine-grained iron of first quality. There is an opportunity in arc welding to duplicate this procedure by preheating the casting to the required temperature before casting or welding the filler material into the original metal, thus delaying the chilling and assisting in cooling the metal slowly. The change from combined to free carbon takes place very rapidly (Fig. 7).

Referring to the first point above, preheating to relieve residual strains and accommodating expansion and contraction will be clearly understood if the following points are kept in mind. When a section of metal is heated or cooled the expansion or contraction which takes place will produce stresses. This may be visualized by comparing the effect to the effect produced by driving a wedge between the sections at the point of heat application. The greatest stress is exerted at a time when the metal is just below the point of fusion, or at the time contraction has taken place. The effect of these stresses in welding practice will be understood by referring to Fig. 8. Assume that item 1 is to be welded at the point marked "W" and that the casting section at the point of welding is 5 x 1 in. An application of welding heat at the point "W" continues to expand the metal at this point until a point just below the fusion is reached. This expansion causes the free end to move outward in order to accommodate the greater bulk of material at the weld, just as if a wedge were being driven into the metal. After the metal solidifies, this greater bulk begins to recede or contract and continues to do so until a point is reached at which the casting assumes atmospheric temperature. With this contraction there is a corresponding movement of the free end of the casting. If,
instead of the casting having the flat section shown in 1, it takes the form of that shown in item 2, where the leg section is similar to three sides of the square; the leg, instead of being free to move, is held more rigidly, causing considerable strain upon the lower side of the section and opposite the weld.

Upon cooling, contraction takes place as in the previous example, causing a severe strain in the lower section. If the casting is solid and the section so heavy that the welding heat does not penetrate all the way through, there is the same expansion and contraction, with their accompanying stresses and strains, which often result in warpage and breakage.

Items 3, 4 and 5 show similar examples, the points "W" representing the places of welding and the points "S" where the greatest strain is exerted. Breakage from expansion and contraction stresses does not always occur at the point of greatest stress application, but at a point where the strength of the section is less than that required to withstand the stress applied at that point. An example of this is shown in item 3, where the weld is made in the
cross member between the legs, and the strain being distributed about the apex of the angle formed at the junction of the legs. If the section of the apex is heavy enough to withstand the energy exerted, the breakage, if any, would then take place in the leg sections, and at a point which is less able to withstand the applied stress at that particular point. A close study of each particular casting with reference to its construction is necessary if proper care and precautions are to be taken.

If the casting is of simple construction it is usually only necessary to preheat it at the points of stress application, as outlined in the previous examples. If the castings are complicated in construction, the problem becomes greater as the intricacy and complexity of the casting increases, in which case it is usually necessary to preheat the casting all over in order to compensate for the liberation of residual stresses, expansion and contraction. In addition to preheating, it is often necessary to after-heat the casting, following the welding operation, if successful work is to be done. Many welders believe they are getting away with something when they weld a casting without preheating, and, though the casting may not crack at the time of welding, it may possess residual stresses which will send it back to the welding table like the proverbial cat.

The only objections to preheating are time required, probable warpage, cost and the heat to which the operator is exposed while welding. The latter consideration most often carries the situation when it should be secondary to all others, as it is possible to protect him from the heat if proper precautions are taken and suitable equipment used.

The development of arc welding of cast iron will probably depend upon the development and use of methods and applications of preheating, and the development of an electrode for metallic arc welding on cold castings which will deposit a ductile metal having a minimum coefficient of expansion.

Satisfactory results can be obtained by the steel metallic arc method and by the carbon arc method, using either cast iron or steel filler rods, if the work is preheated. When using steel filler with either method we have to contend with an area of high carbon
steel which does not machine readily, even when in the annealed state.

Care must be exercised in the manipulation of the pencil with the carbon arc method, as at each spot where the carbon comes into contact with the surface of the casting a hard spot usually results.

In some cases of welding, when steel filler material is used, very good results have been obtained by annealing in addition to preheating. After-heating results in relieving strains caused by welding and in annealing hardened sections of the deposited metal.

One advantage of the preheating method is that the welding operation may proceed as rapidly as it is possible to push it, while welding done by the metallic arc method on cold castings is exasperatingly slow and tedious, since it is only practicable to add the metal a little at a time in order to keep the heat and attendant shrinkage at a minimum.

It is claimed that metallic electrodes of various compositions will produce a soft weld. The truth is that the added material may remain soft, but there will always exist an area of chilled cast iron on the cast iron side of the weld if the materials have been fused. Cutting with a hacksaw through the weld section will reveal the hard area, if one exists.

A few years ago results obtained by electric arc methods in welding cast iron of any sort were questioned. The progress within the past few years has been such, however, that at present very good results are obtained on the better grade castings and passable results are obtained on castings of almost any grade. As more thought is given to the method of procedure in welding of cast iron, and as a better understanding of the conditions under which cast iron can be welded is obtained, the application will become more general and the art will advance more rapidly.

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Do Your Share to Make the Membership Drive a Success
SAFEGUARDING THE OXY-ACETYLENE PROCESS

J. I. BANASH

Before taking up in more or less detail the safeguards which have been developed in connection with the expansion of the acetylene and related industries, possibly it will be of interest to you to review briefly the extent to which acetylene is utilized.

The earliest general use of calcium carbide was for lighting and it is still very widely used on farms, particularly in view of the fact that in addition to lighting, facilities for ironing, cooking and heating water are now provided. There are some 285,000 homes lighted by acetylene at the present time in the United States, and it is estimated that about 80 per cent of these are lighted by what is known as approved or permitted apparatus, that is, apparatus made in accordance with the underwriters' specifications.

Following this early use of acetylene for house lighting and also for village lighting, for which gas was generated on the premises or in a central village station, the gas came into use for lighting mines. At least a million carbide lamps are now in use by miners in this country.

Then we have the very valuable application for lighthouse and buoy lighting, especially at points without an attendant, where a light operates for many months without attention. In this connection a sun valve, operation of which is actuated by the amount of light impinging on it, limits the use of acetylene so that the actual consumption of gas is small and is confined strictly to hours when light is needed.

Then we have the compression of acetylene in cylinders containing certain absorbents that permit it to be safely compressed, transformed and used. In addition to this we have the use of acetylene in conjunction with oxygen for cutting and welding metals, which is the particular subject of discussion to-day. We also have acetylene flare lights used in the open air by contractors and others where brilliant illumination combined with portability is necessary. Such lights are also widely used by fire departments.

These facts are presented to you to impress on you that this is by no means an infant industry but a well established, growing and sound business, and also to impress on you that the people engaged in it or connected with it, including myself, take a very considerable pride in the large part which the industry as a whole has in the daily life of the country. You can readily see from the fore-

* Paper read before joint session of American Society of Safety Engineers and New York Section of American Welding Society, December meeting.
going that almost everyone is affected in one way or another by acetylene, its products or its applications in industry.

Let us now confine ourselves strictly to apparatus and its use. I gather that it would not be pertinent to this particular subject to discuss the safety of welded joints after they are made, though this is a subject of very vital interest and is receiving detailed consideration.

Calcium carbide, as you know, is the product obtained by fusing some form of carbon, usually coke, with lime. We will take this carbide after it is manufactured and put it in a can for transportation. The first move to safeguard the public meets us at once in the specifications of the National Board of Fire Underwriters as recommended by the National Fire Protection Association for the construction of these containers. Next we find that, owing to their service record over many years, containers of standard construction are accepted for transportation on railroads and on vessels (even those which carry passengers) and the rule-making authorities have not yet had occasion to regret this. It has been stated that calcium carbide is an explosive, but, as you all know, calcium carbide will not burn, and if kept dry there is little if any hazard. In fact, during the war carbide shipped from this country to France was actually covered with mud after sinking into the ground from the weight of the pile and was recovered without injury. There have been a few instances of losses because firemen insisted on opening the cans during a fire and pouring water on the carbide, but such cases we hope will not occur any more in this enlightened age.

TO MAKE ACETYLENE

If water is applied to carbide or carbide to water the simple reaction gives acetylene. Acetylene generators are merely devices for bringing the carbide and water into proper contact with each other and for taking care of the gas after it is generated and dispensing it under definite pressure to the service line. Two classes of acetylene generators are recognized—one is the class which generates gas at a pressure not over one pound per square inch and the other at a pressure not over fifteen pounds per square inch. Although everyone probably knows it, it cannot be out of place to repeat that free acetylene should not be used or allowed anywhere at pressure greater than fifteen pounds per square inch. This is recognized by all constituted authorities and forms part of almost every set of regulations on the subject, and such regulations almost always explicitly prohibit the use of liquefied acetylene owing to its hazards.

Now before going into the specific safeguards thrown around the generation of acetylene, let me say right here that one of the most serious hazards, especially in oxy-acetylene work, is using a generator which is too small, necessitating frequent charging. It
is hazardous to open the machine and throw in a few handfuls of carbide from time to time because almost without exception, and experience has proved this, the operator will not change the water. I do not want to go into all the operating instructions, but this matter of completely changing the water whenever carbide is added is important. Naturally this refers only to the type of machine which feeds carbide into the water, which is the type most widely used in this country. Very thorough and adequate protection is thrown around the generation of acetylene by the construction specifications of underwriters' laboratories. These specifications are made up in co-operation with the industry and are revised from time to time as field experience and expansion of the art dictate. Well do I remember when the medium-pressure 15-pound generator designed for supplying gas for welding purposes, was submitted to the laboratories by a manufacturer who had been successful in the lighting generator field. Approval was, of course, out of the question under then-existing construction rules, but a limited recognition was given, the laboratories taking care to point out that there were certain inherent hazards which differed from those in lighting machines. When the gas was generated under pressure up to about fifteen pounds, as in that particular case, a gas bell was not practical, there would be more gas storage in the generating chamber, and a mechanical relief valve of some form was needed. These features are now recognized as essential and proper safeguards have been developed, so that anyone who submits a generator in compliance with present specifications will find that he has a practical machine—one that will work and give satisfaction and at the same time be reasonably safe. I do not wish to go into detail as to specifications, but I will say that they are laid down in such a way that, without making the cost prohibitive, standard machines are made as nearly fool-proof as is consistent with good service and effective operation. Interference arrangements are made so that the charging and recharging and all steps in the operation of the mechanism will be done in the proper order. There are a few high points touching the protective features that ought to be noted especially. One of these is the construction of the pressure relief valve.

Pop valves have been known for many years. They are used on every steam boiler. But when they are applied to an acetylene generator we have a distinctively different service. If the generator operates as intended properly the pop valve will never be called upon to function and thus arises a serious question as to whether or not hard metal to metal seats would tend to stick together if an emergency for their operation occurred. On the other hand, if the valve did blow off, there was some question whether the spring would keep the metal to metal seats absolutely tight, especially as a little lime dust might be blown through the valve. The next suggestion was to use a soft or semi-soft seat at least on one side.
On the other hand, the underwriters feared, and with considerable reason, that one seat would become imbedded in the other and stick to it, either through chemical action or natural adhesion, or because of corrosion or accumulation of dust. The natural answer seems to have been gradually worked out by the requirement that these blow-off valves should be lifted from their seats by the interference mechanism whenever the generator is recharged. This is done without effort as it simply means the extension of a few levers. Therefore, we are certain that the valves will operate, because they are actually moved off their seats every day or two when the generator is recharged and a hard seat in contact with a semi-soft seat now becomes permissible.

The next point is the use of hydraulic back pressure valves. This brings up the fact that house lighting acetylene generators at the present time are not accepted for welding work. If the tip of the blow-pipe becomes clogged, the oxygen pressure may back up through the acetylene line into the acetylene generator because the oxygen is usually utilized at a higher pressure than the acetylene; also, if a mixture of oxygen and acetylene were created, it was feared that a back fire from the blowpipe might be transmitted to the generator. The answer was the requirement for a hydraulic check and several very effective devices having proper checks to keep the water in them have been worked out commercially. This has been done without causing any handicap or hardship to the manufacturers. More will be said about back-firing on flash-backs later.

Now in some cases where it is inconvenient or is not desired to use an acetylene generator, acetylene is supplied in cylinders, compressed to a pressure not in excess of 250 pounds per square inch at 70 deg. Fahrenheit. Nearly everyone became familiar with the small acetylene cylinders through their use on automobiles some years ago. It is a favorite method for lighting trucks, tractors and motorcycles, which usually are not equipped with electric starting and lighting systems because of the rough service to which they would be subjected. Most of you undoubtedly are familiar with the specifications of the Interstate Commerce Commission as developed by the Bureau of Explosives, and therefore I will do no more than to say that these regulations practically have been adopted by all constituted bodies, including the underwriters, and that when the gas is compressed into cylinders constructed in accordance with these specifications and the work is done in a standard manner a reasonable decree of safety is assured. It will interest you to know that the National Fire Protection Association is now working on a set of specifications covering the actual work in recharging plants. Recharging is not what might be called a public hazard, but there was considerable demand for such regulations and tentative rulings are now available for trial and comment. I will be glad to furnish a set to anyone on request. The I. C. C. regulations cover very
stringently the material, the porosity of the filler and the amount of solvent. I may say parenthetically here that it was a wonderful discovery when it was found that acetone and similar chemicals could safely absorb many times their own volume of acetylene under pressure. The I. C. C. rules also cover specifically the safety relief devices. Such cylinders, when in compliance with the regulations, are accepted for transportation in interstate commerce, but cylinders which do not comply are not accepted in interstate commerce and can be used only within a state. I may, if you wish, state it as my personal opinion that all cylinders should be in compliance with the specifications, even though they are not shipped from state to state, but so far it has not been as easy as it might seem for constituted authorities to insist on this feature.

While we are on the subject we may as well mention the protection of the oxygen container. Oxygen is practically always supplied from cylinders, usually at quite high pressure. The pressure is commonly around 2000 pounds per square inch, although in some plants where oxygen is generated locally and chiefly for medical purposes, I think there are still a number of somewhat large cylinders in use at pressures somewhere around 300 pounds per square inch. The oxygen is supplied to the blowpipe through a flexible hose, either from a cylinder near the work, from a manifold which connects a number of cylinders, or from a shop line fed from a lower pressure tank where a manifold is not connected to it. These oxygen shipping containers also are very stringently covered by the Interstate Commerce Commission and the requirements for their construction are very rigid as affecting the material and the actual tests to which a definite number from each lot shall be subjected. In addition to this, retests are made every five years and the safety is determined by the relation of the total expansion to the permanent expansion. It will interest you to know that an analysis record is kept for every batch of metal from which cylinders are made, and every user is supposed to have on file such information as is necessary to trace the devices back to their source, each one, of course, being numbered.

It is obvious that certain hazards in handling high pressure vessels of any kind, whether or not they contain combustible gases, should be avoided, but it is surprising to see how often people violate these rules. For example, no gas cylinder should ever be used as a roller for moving machinery or other heavy material, and many of these cylinders have square bottoms to prevent this. Incidentally every oxygen cylinder is provided with a safety device to operate on a given increase in either pressure or temperature or both.

Now, if we assume that a manufacturer has properly installed his generating apparatus, or that he has merely purchased suitable containers, it becomes necessary before using the gases to lead them to the blowpipes or torches. A generating equipment should have with it regulating apparatus to give suitable pressure. Sometimes
an additional regulating valve is used in the line. Oxygen or acetylene supplied from cylinders should never be used directly from such cylinders without a regulating or reducing valve. These valves usually are connected directly to the cylinders and almost always are of the diaphragm type. For many years serious consideration has been given to such apparatus, not only for use with acetylene and oxygen, but for use with other gases, and there still remain a few distinct problems which at the present moment are subjects of research. Many of the present reducing valves give good service, but the industry has felt that if sufficient research were made a better seat could be developed, and there now is a committee of the Compressed Gas Manufacturers' Association working on this particular subject. A great deal of trouble and expense are involved, and it is hoped that some definite results will be obtained. It is greatly desired to get a seat that will not crack, that will be tight and that will have a long life. The conditions of operation in controlling a pressure of some 2000 pounds are very severe and the problem is not a simple one, although we expect some results shortly. This brings up one of the essential hazards of high pressure reducing valves, among them being the bursting of diaphragms by the admission of the high pressure to the low pressure side, due to failure of the seat or to a small amount of dirt or other foreign material getting between the nozzle and the seat and thereby allowing a slight leakage or "creeping," as it is called. Naturally the low pressure side is not designed to withstand the high pressure, and, if not properly safeguarded, the cap may be blown off, possibly injuring the operator. This has been covered by the construction specifications of underwriters' laboratories, and standard regulators which have been accepted under these regulations are so constructed that, even if the diaphragm does burst under these extreme conditions, no part of the regulator will be blown from it. A similar regulation has been made covering high pressure gauges, so that if the Bourdon tube should burst the glass will not be thrown at the operator, but the vent will occur at some other point. It will interest you to know that a very simple but ingenious apparatus was devised by the underwriters to make this test. They drilled out a piece of shafting to receive the shell of a 32 caliber cartridge from which the bullet and the powder had been removed, so that only the detonator was left. They then rigged up a firing pin and at one side tapped a hole for the admission of the gauge. After many tests a standard charge of smokeless powder was worked out to approximate working conditions. Thus were determined the charge and standard conditions under which all gauges are tested and every one which appears on the underwriters' list has faithfully gone through such tests. In every instance the test has been severe enough to burst the tube without throwing any parts of the gauge at the operator while he is facing it and reading the gauge.
The next feature to consider is the hose which finally leads the gases to the blowpipe. Hose specifications at present are very simple, requiring merely some pressure tests, but development toward a better hose should be encouraged. A point to remember in your work is that hose lines should not be unnecessarily long, they should not be roughly treated, trucks should not be run over them and they should be securely fastened by proper clamps at each end.

We now have brought the gases to the blowpipe or torch, where they are to be consumed and where the heat is to be generated. As you well know, a multiplicity of oxy-acetylene welding and cutting blowpipes or torches are on the market, but again we must refer to the underwriters' laboratories' specifications for construction and advice. Only blowpipes which are constructed in accordance with the specifications should be accepted. These specifications are not very rigid, but they do give a reasonable protection. They are designed to avoid unnecessary hazard from backfiring or flashbacks, and a blowpipe of standard construction will be made so that it will not fall apart, owing to soft-soldered joints, from the heat of backfire before the gases can be turned off. Although I use the words backfire and flashback more or less indiscriminately, some people prefer to make a distinction in that a flashback is a sustained backfire and a backfire, not sustained, is a momentary popping back to the mixing chamber during the work, that is, one which does not put out the flame or withdraw the combustion from the tip to a point farther back.

Let us assume that a responsible manufacturer has purchased a more or less extensive equipment and has followed the sound and conservative policy of insisting that every piece of apparatus be of standard construction, and shall be constructed strictly in accordance with underwriters' laboratories specifications. What next shall he do to safeguard himself and his working force? We will further assume that he has made inquiry and has been given the proper advice to enable him to be certain that the apparatus is installed in accordance with the regulations of the National Board of Fire Underwriters, recommended after many years' study by the National Fire Protection Association. Incidentally I may note that these regulations also are being kept up to date by revision from time to time, when it appears necessary.

The demand for further information led to the development by the National Safety Council of a pamphlet known as Safe Practices No. 23, which takes up the actual operation of the system, particularly from the operator's end, and explains the relation of the various parts and the proper sequence of operations. If a man lays down the rule in his factory that all these regulations of construction, installation and operation shall be followed, there is no reasonable doubt that he has done all that can be required in the light of present knowledge to safeguard the employees, and it is also the consensus of opinion, not only of fire and casualty insur-
ance companies who carry the risk, but also of engineers and others thoroughly versed in the art and competent to comment, that a quite reasonable and acceptable degree of safety has been attained.

In spite of more or less recent statements that the use of the blowpipe itself involves undue hazard, owing, let us say, to backfiring, the fact remains that with the protection which has been outlined in this paper those hazards either are not there or are not apparent. There is no single fatality on record, as far as I can determine, from the use of an oxy-acetylene blowpipe, either in welding or cutting. Furthermore, in the most extensive experience nothing more than simple burns and related injuries are recorded. I will give you a specific instance of one firm which has under its direction the operation of some 25,000 or more blowpipes. It has been estimated that their employees directly operate or instruct operators who each year are involved in something over 8,000,000 man torch hours of welding and cutting, not only without a fatality in this service which has covered many years, but without a record of a single serious accident. Of course, burns and slight injuries inherent in all mechanical processes cannot be avoided.

Just a few words of general advice. It is obvious that explosions will occur when repairing vessels that have contained inflammable or gaseous substances without purging the vessels thoroughly. Proper ventilation obviously should be provided when welding in confined spaces. Using cylinders full of gas to support work while welding or cutting is inherently dangerous. Building up acetylene pressure of more than fifteen pounds per square inch in a hose or elsewhere, in a free or undissolved state, may result in an accident. This may be caused, when a job is finished, by men shutting off the gas supply at the blowpipe instead of at the tank, with the result that if there happens to be a leaky regulator the pressure is built up in the hose, and then, when the blowpipe is relighted, there is likely to be an explosion. A similar hazardous pressure may be built up when using a very long length of hose, if a considerable pressure is required at the delivery end, because a considerably greater pressure must be imposed on the receiving end to overcome the friction, unless a suitable diameter of hose is used.

Now in closing let me decry the tendency of reporters who all too frequently blame acetylene for accidents in which it is not involved. I think that I am entirely safe in saying that at least 70 per cent of the accidents attributed to acetylene were not so caused. Many of you have heard me give specific facts on this subject, and I will be glad to advise anyone interested as to details. I do not want to consume more of your time at present, but I may say that even after pointing out to a newspaper that error had been made the retraction usually is in a very inconspicuous place, if it is made at all, and never can have as much effect in offsetting the damage as the original article had in causing it. Misleading information of every kind has been published in the newspapers, from that of attributing
to acetylene the property of being used for inflating balloons to statements that it is used in refrigerating systems. The non-technical writer is very careless of the terms which he uses, and when the news value has died out of an article or out of any subject it is very difficult to revive it. Sometimes it will do more harm than good.

TECHNICAL QUESTION AND ANSWER COLUMN

From time to time the Society is requested to furnish technical information on various welding problems. This information in many cases is of general interest and in order that it may be available to our members we will publish in the proceedings under the auspices of our research department, The AMERICAN BUREAU OF WELDING, a Technical Question and Answer column. Although the statements given below are expressions of opinion of competent engineers they do not involve the Society or Bureau in any way. The Society does not intend through the medium of this column to solve those welding problems which should fall in the province of a Consulting Engineer.

RELATIVE MERITS OF ACETYLENE AND HYDROGEN

Question 1

What are the relative merits of acetylene and hydrogen for welding and cutting applications?

Answer to 1

Hydrogen is all right for cutting and gives equally as good results as acetylene, although it is somewhat slower in starting a cut because of its lower flame temperature.

For welding it is quite unsatisfactory. Its flame temperature being less, it will not melt metal as quickly, but this is unimportant and the main objection to its use is that a neutral flame cannot be used because the burning of the hydrogen with oxygen produces water vapor which, in contact with the hot metal, oxidizes it rapidly. To avoid this it is necessary to use a great excess of hydrogen, probably about four times the theoretical amount. This cools the flame down so much that it will not melt the metal except with very thin sections—say about 1/16 in. thick. Even with this increase in hydrogen there is still considerable oxidation. With either welding or cutting special apparatus is necessary in the way of tips, back flash chambers, etc., to make it safe to use so that unless you have special reasons—such as very low cost of hydrogen—for using it, it is better to use acetylene.

S. W. MILLER,
Rochester Welding Works.

Answer to 1

The fact of the matter is that hydrogen is of little value as a heating agent for welding in comparison with acetylene.
The oxy-hydrogen flame lacks not only the heat necessary for welding steel but the very valuable characteristic of the oxy-acetylene flame of a concentrated bulb or cone that may be localized exactly where needed to produce fusion. The heat of the oxy-hydrogen flame is diffused over a large area and consequently is hard to manage where a large volume of heat is required.

Another reason why oxy-hydrogen is not good for welding steel is the practical impossibility of preventing oxidization. The welder has no visible proof when balancing the oxygen and hydrogen to produce a neutral flame as is the case with oxy-acetylene.

For lead burning, of course, oxy-hydrogen torches are preferred by many expert lead burners, chiefly perhaps because they were trained to use hydrogen and know just how to handle it. As a matter of fact, though, excellent lead-burning work can be done with the oxy-acetylene torch and the control is more easily learned by a new beginner than with oxy-hydrogen.

Oxy-hydrogen cutting torches perhaps have some advantage over oxy-acetylene for very heavy work. The matter is in dispute and I am unable to positively decide. We know that acetylene cutting torches operate successfully on all thicknesses of steel up to 18 or 20 in., beyond that so little cutting has been done that few data are available. Rumors come to us that oxy-hydrogen torches have been used in the armor plants for cutting up to 30 in. successfully.

The diffused heat produced by the oxy-hydrogen flame is useful in welding aluminum, brass and bronze. Perhaps it might be said to have some advantages for these classes of work over acetylene. When welding aluminum it is necessary to preheat a comparatively large area before welding can be done. When using oxy-acetylene the welder avoids concentrating the heat until the metal has reached the temperature at which local fusion can be safely produced. Brazing, also, generally requires diffused heat through a considerable mass simultaneously.

In conclusion we would sum up the matter about as follows: Oxy-hydrogen may be used successfully for lead burning, aluminum welding, brass and bronze welding, general brazing and for cutting. Cuts produced with oxy-hydrogen are said to be very smooth. The consumption of oxygen, however, is greater than with acetylene.

F. E. Rogers.
Davis-Bournonville Company.

SPOT WELDING HIGH CARBON STEEL

Question 2

Will you kindly furnish us with information on spot welding of
high carbon steels, as we have been advised that 0.50 to 0.65 carbon steel cannot be spot welded.

Answer to 2

Regarding the spot welding of carbon steel of 0.50 to 0.65 carbon, such steel can be spot welded within certain limits of thicknesses, but in all cases these spots will be more brittle than the surrounding metal and consequently would have to be heat-treated if any great service was required from the weld.

W. REMINGTON,
Thomson Electric Welding Company.

Answer to 2

Would say that high carbon steels are being successfully welded in a number of different industries in the United States, and the only reason why it has been occasionally branded as not being a success is due to the fact that the operator was not familiar with the process.

In the welding of high carbon steel, if the stock is reasonably thin, the current flows through between the welding points when the machine is in operation and heats the very small area in contact with the points very rapidly. Immediately upon completion of the weld, the current being turned off, the surrounding metal being cold, the radiation is excessive. The effect is identically the same as if you poured cold water on a piece of heated steel; it makes it as hard as glass.

To make a successful weld you should use your welding current at a lower voltage than you would for welding the same thickness of stock of soft steel, so that it does not heat the metal so rapidly, and then keep the current on sufficiently long so that the surrounding metal is what you might call thoroughly annealed. That is, you heat enough area so that the point at which the weld is made is not chilled so quickly as to temper it. You will find that you will have no difficulty whatever in making a good substantial weld, and one that will hold.

The writer might add that there is probably no fixed rule to follow; that is, you could not make a fundamental statement and have it apply in all cases. As a rule, thin stock is easier to weld than heavy stock. This may be due more to the fact that there is a greater variety of medium duty welders available that can be adjusted for various conditions of welding thin stock, than to any fundamental difficulty of welding heavy stock. In the past there has not been a demand for welders to handle much over 3/16-in. stock, and few concerns have machines of greater capacity. Suppose you had a machine that would weld low carbon steel of this thickness; if the transformer was of 25 kw. capacity you would probably use full voltage. If you wanted to weld some other
material of the same thickness that required a lower voltage, the chances are you would not get the kw. capacity you wanted.

It might be difficult to weld high carbon steel under some conditions. If you have a series of welds to make over a distance of several feet it is desirable to make the welds quickly, and with a high current, to prevent pulling and buckling. The metal furniture manufacturers follow this practice in making large cabinets, etc., where they use thin sheets of considerable area, otherwise the sheets will buckle, and it cannot be prevented. We have been up against this on elevator cagings and partitions. If a proposition was put up to us to handle high carbon steel along these lines it would no doubt require considerable thought. However, there seems to be a way around most welding problems, and there would probably be one for this.

J. E. Chamberlain,
The Federal Machine and Welder Company.

Answer to 2

During the war we were very successful in welding high-speed tool steel to machine steel shanks by the spot welding process. Formerly this work has been done with acetylene gas. Much time and money was saved in repairing lathe tools by using the spot welding process.

It is possible, therefore, to weld carbon steel to machine steel. The secret of the operation lies in the proper annealing of the weld after it has been made. We have also successfully butt welded high-speed steel drill bits to machine steel shanks. In order to properly do this, however, it was necessary to place the welded part in an annealing oven and allow it to cool very slowly. If the annealing operation is omitted the weld would show no strength.

Jos. A. Osborne,
American Car and Foundry Company.
ITEMS OF INTEREST

*A PAINT THAT WILL NOT REFLECT ULTRA-VIOLET RAYS

By W. S. ANDREWS
Consulting Engineer Department, General Electric Company

THE dangerous invisible rays of ultra-violet light, as produced by the electric arc in welding of iron or steel, can be reflected in the same way as visible light. Ordinary spectacles do not, therefore, provide entire protection to the eyes, because they fail to obstruct the rays which may be reflected from objects in a sidewise direction and in many cases these rays may have a dangerous intensity. For this reason operators should always wear goggles to cut off these side reflections, and when engaged on heavy welding work, suitable helmets or masks, and gloves should be worn to protect the otherwise exposed skin of face, neck, hands and arms.

Almost all surfaces that reflect visible light will also reflect the invisible ultra-violet rays to a greater or lesser extent, but there is at least one material which, although pure white, absorbs them completely, so that it would appear jet black if we could see it by this light alone. This material is zinc oxide or Chinese white, and its curious property, as above stated, was discovered by Professor R. W. Wood. While experimenting along these lines he covered surfaces with various white paints, such as white lead, lime, zinc oxide, etc., and found that although they could hardly be distinguished one from the other under visible light, strange to say, the surface painted with zinc oxide absorbed all the ultra-violet radiation, so that it reflected practically nothing but harmless visible light.

As a further source of safety to operators and chance lookers-on it is evidently desirable that the walls and ceilings of shops where electric arc welding work is done should be covered with a paint that will absorb the ultra-violet radiations, so that their reflecting power may be reduced to a minimum. Paint made with zinc oxide, that is, Chinese white, will answer this end, but pure white would naturally produce too dazzling an effect, so it is best to tone it down to a light gray with lampblack, which only slightly affects its ultra-violet absorbing quality. Also the paint must be mixed so as to produce a dead surface, as even Chinese white when made so that it dries with a glossy surface, will reflect the dangerous rays. Perhaps the best adhesive medium is glue water, such as is used with lime for kalsomining, as this is cheaper than oil, and the paint so made will dry with a smooth unglazed surface. For covering any considerable wall surface it will be found convenient and economical to apply it with a paint sprayer.

*Reprinted from the October, 1921, issue of G. E. Review.
AN INVESTIGATION OF THE FATIGUE OF METALS

The members of the Society will be interested to know that The University of Illinois has just issued a bulletin giving the results of the researches of the Committee of the National Research Council on Fatigue of Metals. This bulletin includes a description of the early history of fatigue testing, organization of the committee, materials, tests and apparatus used in the investigation, the test data and results, and the discussion of the latter, description of short time tests of determining endurance limits, subjects needing further investigation, bibliography and conclusions. It is particularly interesting to know that the problems of fatigue come to the attention of the National Research Council through the Welding Committee of the Emergency Fleet Corporation (the predecessor of the American Welding Society). In fact the rotating beam type of machine which was largely used in making these investigations was developed by Mr. Farmer for the Welding Committee.

Although fatigue failures of metal parts subjected to rapidly alternating stresses have been recognized for many years, the recent era of high speeds has yielded cases of great number and importance—in steam turbine shafts and rotors, airplane engine crankshafts, hulls of steel ships, axles and shafts of railway cars, motor-cars and trucks, and many machine parts. Such parts occasionally fail under ordinary service conditions without general distortion or other symptom, even when the material is highly ductile. These failures are found only in parts subjected to alternations of stress repeated in some cases millions of times, and, therefore, are attributed to fatigue of the metal.

Recognizing the value of the results of these investigations to the industries of the country, Engineering Foundation made a grant of $15,000 a year for two years. The experimental work was done at the University of Illinois, through its Engineering Experiment Station, under the joint auspices of the Division of Engineering, Engineering Foundation and the University of Illinois. The University furnished certain services, laboratory space and other facilities, a contribution equivalent to about $6,000 a year. In the summer of 1920 the General Electric Company agreed to contribute an additional sum of $30,000 for an extension of the work to include 3 per cent and 3½ per cent nickel steel, placing no restriction on the publication of the results.

The work of this Committee is an excellent illustration of cooperative research. Copies of the complete bulletin (No. 124) may be obtained from the Engineering Experiment Station of the University of Illinois, Urbana, Illinois.
CURRENT WELDING LITERATURE

TO OBTAIN COPIES OF PAPERS—The Engineering Societies Library is prepared to supply copies, translations, or abstracts of any papers in the Library at the following rates:

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Hammer-Welded Steel Pipe—How Made and Wherein it Excels, Raw Material (Vol. 4, Nov., pp. 384-391). In the production of large diameter pipe the hammer-welding process offers advantages over the butt-weld and lap weld methods of pipe welding. Rivets and projecting ribs are eliminated and a smooth seam is obtained. The steel plates used are either bent cold, or heated and bent. Article is based on data furnished by the National Tube Company's engineering staff.

Influence of impurities in Mild Steel on Autogenous Welding. Revue de la Soudure Autogene, October. A large carbon content is harmful. The silicon content should be as small as possible. A large enough manganese content seems to compensate for the bad effects of silicon and sulphur. Sulphur is the most harmful element. Traces of chromium and nickel have not shown any disadvantages. This discussion is an abstract of test results published in Switzerland.

from hazards than many others whose elements of danger are so familiar to
us that they are sources of scarcely any public alarm at all. In most "acyety­
lene" accidents reported, it is found upon investigation that acetylene had no
connection whatsoever with the accidents.

192, Nov., pp. 561-583. Discusses resistance, carbon arc and metal arc weld­
ing, metallography of welds, metal transfer, electrodes, reliability of welded
joint, electrical characteristics and equipment and automatic arc welding.

The Scientific Side of Welding, E. A. Atkins (Acetylene and Welding Jour­
nal, London, November). Imperfect penetration causes welds to pull apart
easily. Slag inclusions weaken the joints perceptibly. Oxidation, caused
usually by use of oxidizing flame, results in a brittle structure. Overheating
causes large grain growth, a condition which can often be relieved by hammer­
ing. Overheating is not the same as burning. The latter defect can be re­
moved only by remelting. Excess acetylene carbonizes the metal. Hammering
welds is a great advantage. Impure acetylene is harmful, adding sulphur and
phosphorus.

Semi-Automatic Arc Welding Lead, Railway Electrical Engineer, Vol. 12,
Dec., p. 478. Device for use in conjunction with G. E. automatic arc welding
head, which retains the continuous features of the automatic apparatus, yet
allows the operator to direct the arc as required by conditions of the work.

Survey of oxy-acetylene welding, Lorn Campbell, Jr., Journal, Society of
Automotive Engineers, Vol. 9, Nov., pp. 320-322. Oxy-acetylene welding as a
factor of efficiency in manufacturing. Recommended practice with special ref­
erence to mild steel. Steel-welding apparatus is described and the subject
of filler-rods considered.

Tests of Welded Tanks, S. W. Miller, Power, Vol. 54, No. 22, p. 814. Some
recent tests of welded tanks. The tests have not been completed; the tanks
will be tested to destruction. By using a material of low tensile strength,
nickel steel welded rod, and by welding the longitudinal seams with a double V,
perfectly safe welded pressure vessels for any purpose can be made.

Tube Bending and Welding, J. F. Springer, Automobile Dealer and Re­
pairer, November. Methods of making bends without crushing the tubing, and
making butt welds in small pipes.

Welding Cast Steel. Das Schweissen von Stahlguss. L. Trubeit, Giesserei-

Welding of a Caulking Edge on a Boiler or Tank, Power House, Vol. 14,
Nov. 21, pp. 30-31. Putting refractory plates and angles in place, repairing
broken end of a shaft, filling in scored cylinders.

Welded Locomotive Tender Tank, J. W. Murphy. Railway Electrical En­

Welding Rods for Oxy-acetylene welding, J. R. Dawson, Acetylene Journal,
consideration in the selection of welding rods, welding rod materials and their
composition, Inspection and tests of rods, physical tests of welds, microscopic
examination.

Welding a Tractor Cylinder Block in the Open Air, David Baxter (Ameri­
can Blacksmith Auto and Tractor Shop), Vol. 20, Nov., pp. 361-3. The cylin­
der block is covered with asbestos paper and preheated an hour or so with
kerosene torches, then welded without exposing any more of the surface than
is necessary. After welding the preheating flame is kept on it for about five
minutes, and the casting is allowed to cool slowly under a complete covering
of asbestos paper.
Notice to Members

The Proceedings of the Society is a medium of publicity which is open to all its members. We invite you to send us any article that you may write on welding.

Welders are particularly requested, when they successfully complete a difficult job, to make photographs of it and send them along with details of how the work was done.
Technical Bulletins

These Bulletins are published under the auspices of the American Bureau of Welding. The Bureau is a joint advisory board of the American Welding Society and the Division of Engineering of the National Research Council on welding research and standardization. It acts as the Research Department of the Society.

BULLETIN No. I

Standards for Testing Welds

These Standard Tests Comprise

(a) Shop Standard: A simple standard test for such purposes as checking the work of a welder, testing a new lot of welding wire, and testing the effect of some change in conditions.

(b) Commercial Standard: For cases where more than one kind of test should be made but where the circumstances do not justify a complete investigation.

(c) Research Standard: When a complete investigation of a weld is to be made for research or other purposes, all test and examinations are made which will contribute any information in regard to the characteristics of the weld.

Price per copy—Members 25 cents, Non-members, 50 cents.

BULLETIN No. II.

Welding Wire Specifications and Folios

The specifications and folios are based on the data collected by the Welding Wire Specifications Committee as to the chemical analysis of welding wire used for both gas and electric welding in railroads, shipyards and other places and the service results obtained from the use of such wire.

Price per copy—Members 25 cents, Non-members 50 cents.