what regular manner. Each class of gas mixtures must be studied individually with regard to the probable limits of variation of every constituent; but unless the mixtures are extremely complex a method can generally be found for indicating the composition of the mixture, although the data may not be expressed in the familiar units of percentage of the original mixture. Thus when several constituents are determined in a single mixture, the amount of some of them must generally be expressed in percentage of the residue remaining after the removal of other constituents. The data obtainable should not be less useful to a plant operator on that account after he has learned to interpret them.

SUMMARY

The limitations and advantages of the method of gas analysis depending upon thermal conductivity, which was described in an earlier paper, are discussed.

Several novel expedients are described by the use of which the method may be employed for the analysis of a great variety of gas mixtures of industrial importance, and their specific application is shown by many examples.

LABORATORY CONTROL OF WHEAT FLOUR MILLING¹

By Benjamin R. Jacobs and Olaf S. Rask

FOOD CONTROL LABORATORY, BUREAU OF CHEMISTRY, U. S. DEPARTMENT OF AGRICULTURE, WASHINGTON, D. C.

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This article does not aim to present much information which might be called original in the strictly scientific sense. Its purpose is rather to point out an analytical procedure for the cereal chemist, particularly the flour-mill chemist, that differs considerably from those he ordinarily follows. This procedure is modeled after those used in control laboratories of industrial plants like smelters, sugar-beet factories, and others, where the process is one of refining or extracting the desired product from crude sources. In the laboratories of such plants samples of raw materials and of the different finished products are analyzed, thus keeping a check on the efficiency of factory operations. The flour-mill chemist ordinarily confines his activities to tests on the finished flour, but would increase the value of his services appreciably by including determinations of the flour content of wheat as it is received at the mill, and of the offal as it comes from the bins. From the results of such analyses the efficiency of milling operations may always be known. These results may also have other applications, as will be pointed out later.

THE WHEAT KERNEL

For milling purposes the wheat kernel may be regarded as composed of three distinct parts: the bran or outer seed coats, including the aleurone layer, the embryo or germ, and the inner endosperm or flour-producing portion. These different parts can be seen by cutting the kernel transversely or longitudinally. It is more difficult to determine what percentage of

the whole kernel each constitutes. This can be done only by a slow and tedious process of mechanical separation which Aimé Girard¹ performed as follows:

The kernels were soaked in water until they became plastic but not too soft, a treatment which required several days. Experiment showed that only an inconsiderable amount of material dissolved in the water in this process. The several layers of the seed coat were next removed by means of a scalpel, dried at 105° to 110° C., and weighed. The dry seed was split along the groove, and the germ was removed with pincers. Girard found the composition of the kernel to be

	Per cent
Bran (outer seed coats).....	14.36
Germ.....	1.43
Endosperm.....	84.21
TOTAL.....	100.00

Fleurent² reports the composition of three different wheats as follows:

	Average Wt. of Kernels Gram	Endosperm Per cent	Embryo Per cent	Bran Per cent
Russian.....	0.030	84.95	2.00	13.05
Algerian.....	0.048	84.99	1.50	13.51
Canadian.....	0.037	84.94	2.05	13.01

BRAN—The bran functions as an exo-skeleton or protective structure for the rest of the kernel, and is adapted to this purpose in chemical composition and physical structure.

Histological examination of cross-sections of the wheat kernel shows that the bran coat consists of several layers and membranes. The first three outer layers, called the epicarp, mesocarp, and endocarp, together constitute the pericarp. Beneath the endocarp are found, in the order named, the seminal tissue, the hyaline band, and the protein or aleurone layer. Botanically, the aleurone layer belongs to the endosperm, and is sometimes called the outer endosperm, but in commercial milling processes it is always separated with the bran, to which it adheres very firmly, and it may, therefore, be regarded as one of the seed coats of which the bran is composed.

The table of Girard (Table I) gives quantitatively the location of the different substances that are found in the outer covering, expressed in per cent of the entire bran coat.

TABLE I				
PERICARP				
Water.....	3.58			
Non-nitrogenous fiber.....	24.43			
Nitrogenous material.....	2.41			
Ash.....	0.58	31.00		
SEMINAL TISSUE				
Water.....	0.92			
Non-nitrogenous material.....	5.06			
Nitrogenous material.....	1.25			
Ash.....	0.46	7.69		
HYALINE BAND AND PROTEIN LAYER				
Water.....	7.23			
Cellulose material.....	29.61			
Nitrogenous material.....	15.21			
Fatty material.....	5.60			
Ash.....	3.66	61.31		
TOTAL.....		100.00		

By adding the percentages of each substance as given separately for the three different regions in the preceding table, Girard computed the composition of the entire bran as follows:

¹ "Le Froment et Sa Mouture," 1903, pp. 28-44.

² *Compt. rend.*, 124 (1896), 327.

¹ The authors desire to express their thanks to Dr. I. K. Phelps for his helpful suggestions in this work and for his criticisms in the preparation of the manuscript.

Water.....	11.73
Cellulose material.....	59.10
Nitrogenous material.....	18.87
Fat.....	5.60
Ash.....	4.70
TOTAL.....	100.00

Girard found 17.6 per cent of the bran to be water-soluble. Very dilute hydrochloric acid extracted 43.60 per cent more, 5.75 per cent of which was nitrogenous material, 33.5 per cent cellulose, and 4.35 per cent mineral matter. Treatment of the remainder with alkali removed 10.6 per cent, consisting mostly of nitrogenous matter.

THE GERM—The germ is the center of all physiological activity in the kernel. It consists of an embryonic plant with a cluster of leaves above and a radicle or embryo root below. On the side next to the endosperm is the scutellum, the connecting organ between the germ and the endosperm. The germ and scutellum contain active ferments and enzymes whose function it is to convert the reserve material of the endosperm into soluble matter, to be assimilated by the germ in the process of germination. The cells of the germ contain nitrogenous substances mixed with fatty matter, in the midst of which is the nucleus. All this material is soft and easy to modify as compared with the resistant substances in the other parts of the kernel. It is a well-known fact that mill products containing appreciable quantities of germ substance undergo decomposition more readily than do those which are relatively free from germ. This is probably due to the enzymes of the scutellum and to the sensitive nature of the germ proper. Table II gives the composition of the germ as found by Girard:

TABLE II	
WATER.....	11.55
INSOLUBLE	
Fatty material.....	12.50
Nitrogenous material.....	19.32
Cellulose.....	9.61
Mineral matter.....	0.80
	42.23
SOLUBLE	
Nitrogenous matter.....	19.75
Non-nitrogenous matter.....	22.15
Mineral matter.....	4.50
	46.40
TOTAL.....	100.18

THE INNER ENDOSPERM—The inner endosperm consists of inert material destined to serve as a food supply for the young plant in the process of germination. Its chemical constitution corresponds very closely to that of the purified and uncontaminated first middlings, which is practically pure endosperm. A histological study of the inner endosperm shows that it is made up of large cells with transparent walls, filled with a compact mass of gluten, in the midst of which are granules of starchy material. The parts nearest the aleurone layer are richest in gluten. According to Fleurent gluten consists of gliadin, glutenin, and very small quantities of conglutin. The gluten at the pericarp contains more glutenin and less gliadin than that at the center. The quality of a flour for bread-baking purposes depends largely on the ratio of gliadin to glutenin in its gluten. Much research has been done to ascertain the optimum ratio but no definite conclusions have as yet been reached.¹

¹ Harry Snyder, Minnesota Station, *Bulletin* 54, 42; *Ibid.*, 63; Fleurent, *Compt. rend.*, 126 (1898), 1374; 123 (1896), 755; F. B. Guthrie, *Agr. Gazette*, N. S. Wales, 7 (1896), 583; H. A. Guess, *J. Am. Chem. Soc.*, 22 (1900), 263.

MILL CONTROL

The object of commercial milling processes is to separate the three anatomical parts of the wheat berry as well as to reduce them to the desired granulation. Although it must be realized that proper and uniform reduction is essential, the efficiency of milling operations depends much more upon the completeness and the exactness of this separation than on the grinding or reduction. The function of the milling chemist, in addition to those already suggested, should be to trace the extent of the separation through its successive stages. On special occasions he may be of great assistance to the miller by making exact chemical measurements of endosperm (or flour) and offal (or bran) content of mill stocks before and after adjustments have been made on any particular machines. The endosperm, germ, and bran are composite substances which do not lend themselves to measurements by direct chemical methods, but a knowledge of their content in any stock may be obtained through a quantitative determination of some compound which is characteristically associated with these different parts of the wheat berry.

Table III, compiled from analyses made in the Food Control Laboratory on the best obtainable commercial products, shows approximately the chemical composition of the different parts of the wheat kernel in terms of those constants which are most commonly determined on mill products in a control laboratory.

	First Middling Flour (Endosperm)	Commercial Bran	Commercial Germ
Ash.....	0.368	6.45	4.47
Protein.....	12.08	16.49	29.89
Cold water extract.....	4.61	11.84	...
Acidity.....	0.08	0.65	...
Fat.....	0.75	3.58	10.02
Pentosan.....	2.25	22.72	5.38
Sugars.....	...	...	12.82
Starch.....	68.78	9.07	7.30
Moisture.....	12.08	13.00	13.00

A study of this table will show that the three different parts of the kernel have their characteristic constituents. Starch constitutes about 70 per cent of the inner endosperm and does not exist in either of the other parts, as may be demonstrated by a microscopic examination of pure bran coats or pure germ. The starch content of the samples of commercial bran and germ must, therefore, be regarded as due to endospermic contamination, and indicates imperfect separation in the milling process.

Pentosan may be considered the characteristic constituent of the bran, since its percentage is higher than that of the other bran constituents, while in the other parts its content is low. The figures in Table III represent the pentosan content of commercial mill products which are contaminated one with another. It is quite probable that most of the pentosan content in the sample of commercial germ is due to the presence of bran tissue, and that practically all of the pentosans in the offal come from this source.

Fat or ether extract is the characteristic constituent of the germ and aleurone layer. The following experiments were made in order to ascertain in a general way the distribution and location of fat in the wheat kernel. Kernels of different types of wheat were cut in two transversely, and the ends containing the germ

were kept separate from the other ends. Fat determinations or ether extractions were made on the separate head and germ ends and also on the entire wheat. The results of these analyses, given in Table IV,

TABLE IV—DISTRIBUTION OF ETHER EXTRACT IN WHEAT

DESCRIPTION	Percentage of Ether Extract in—			Percentage of Kernel Represented by Germ End	Per cent of Total Fat Con- tained in Germ End
	Wheat	Head	Germ		
No. 1 Hard R. Sp. Marquis..	2.32	0.91	5.34	31.8	73.4
Red Russ. West. Soft Winter.	1.90	0.96	5.22	22.1	60.7
Blue Stem Western White....	1.80	0.79	4.05	32.0	72.0
Durum from N. D.....	2.44	0.99	8.98	18.1	66.6

indicate that the greater portion of the fat is associated with the germ. With the aid of facts which have already been brought out in Tables I, II, and III, further conclusions can be reached regarding the distribution and location of fat in the whole kernel. The fat content of the various parts as given in these tables are assembled in the following table:

	Per cent
Pericarp.....	0.0
Seminal tissue.....	0.0
Hyaline band + aleurone layer.....	5.6
Germ.....	12.5
Inner endosperm.....	0.75

From these figures and those on page 899 giving the composition of the kernel, the percentage of the entire kernel, which the fat from each part constitutes, and the percentage of the total fat contained in each part may be calculated:

SOURCE OF FAT	Per cent of Kernel	Per cent of Fat
Bran, including aleurone layer.....	0.804	49.8
Germ.....	0.1788	11.08
Inner endosperm.....	0.631	39.1
TOTAL.....	1.6138	99.98

These figures show that about three-fifths of the fat is concentrated in the hyaline band, aleurone layer, and germ, which constitute only about 10.3 per cent of the kernel. These parts belong to the offal. The inner endosperm constitutes the only true flour-producing portion of the wheat kernel; hence, ideally pure flour will contain no more fat than does the inner endosperm. This ideal condition is, perhaps, more nearly approached in the modern roller process than in the old burrstone process, where translocation of fat might more readily take place as a result of pressure and subsequent diffusion. A greater fat content in any mill stream must, therefore, be regarded as evidence of the presence of offal.

As has been stated previously, the germ and the scutellum contain a large number of enzymes, oils, and other compounds of great chemical activity, which seem to be intimately associated with the rapid decomposition of flour containing germ matter. The Food Administration realized the importance of this fact by allowing millers to remove as much as 5 per cent of low-grade stock from "war flour" to insure as complete a removal of germ substance as possible. Even during the period of flour shortage the improved keeping qualities of the remaining 95 per cent more than compensated for the sacrifice of this fraction. In view of these facts, every miller who wants to be assured of the keeping qualities of his flour should take special precautions to keep its germ content as low as possible. In order to know whether his pre-

cautions are effective, he should make fat determinations in the finished product. Starch, pentosan, and fat determinations in wheat and in mill products may thus be used as measures of the inner endosperm, bran, and germ content, respectively, of these products.

EXAMINATION OF COMMERCIAL MILL PRODUCTS

The procedure outlined in the preceding paragraph has been tested in commercial products, samples of which were sent to the Food Control Laboratory by the mills that produced them. They consisted of the cleaned wheat, and the flour and offal into which it was milled. Statements concerning flour yields were also sent by the mills. Starch and pentosan determinations were made by official methods as given in Bureau of Chemistry *Bulletin 107*, revised, the diastase method being used for starch. Moisture was determined by drying in a vacuum oven to a constant weight, which required about 6 hrs. The results of these determinations, together with certain ratios and other calculated values, are assembled in Table V. Each group consists of a sample of cleaned and scoured wheat, and the flour and offal into which it was milled.

TABLE V—CHEMICAL AND CALCULATED CONSTANTS OF COMMERCIAL MILL PRODUCTS

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Wheat....	7.30	58.81	..	..	..	..	83.6	28.2	..
Offal.....	20.78	19.66	23.1	..	..	..	27.9	27.6	..
Flour.....	3.19	70.42	76.5	76.6	77.2	1.42	..	..	91.5
Wheat....	7.81	53.71	..	..	..	..	81.7	29.0	..
Offal.....	20.48	18.63	24.9	..	..	..	28.3	27.4	..
Flour.....	3.07	65.71	75.1	72.8	74.6	1.52	..	..	91.9
Wheat....	8.19	50.20	..	..	..	..	79.3	27.3	..
Offal.....	19.06	23.41	30.91	..	..	..	37.0	28.4	..
Flour.....	3.20	63.28	69.14	72.3	68.5	1.58	..	..	87.2
Wheat....	7.35	55.40	..	..	..	..	83.0	27.4	..
Offal.....	29.91	19.35	25.8	..	..	..	28.9	28.1	..
Flour.....	3.24	66.80	74.2	76.8	76.0	1.496	..	..	89.4
Wheat....	7.59	57.40	..	..	..	..	84.5	31.9	..
Offal.....	21.30	21.00	25.8	..	..	..	30.9	29.5	..
Flour.....	3.12	67.90	74.2	75.5	77.6	1.473	..	..	87.8
Wheat....	7.54	54.30	..	..	..	..	82.9	29.8	..
Offal.....	20.82	19.10	25.7	..	..	..	29.1	28.2	..
Flour.....	2.95	65.50	74.3	74.3	75.8	1.526	..	..	89.6

- (1) Pentosan content on 13 per cent moisture basis
- (2) Starch content on 13 per cent moisture basis
- (3) Yield of flour and offal as reported by the mill, expressed in per cent of the wheat
- (4) Yield as calculated from the pentosan content
- (5) Yield as calculated from the starch content
- (6) Flour conversion factor
- (7) Flour content of wheat and offal calculated on starch content by use of conversion factor
- (8) Pentosan content of flour-free products
- (9) Milling efficiency

FORMULA 1:

$$\text{Flour yield} = \frac{(\text{Starch in wheat} - \text{Starch in offal}) \times 100}{\text{Starch in flour} - \text{Starch in offal}}$$

FORMULA 2:

$$\text{Pentosan content of flour-free wheat} = \frac{\text{Pentosan in wheat} - (\text{Flour in wheat} \times \text{Pentosan in flour}) \times 100}{100 - \text{Flour in wheat}}$$

Example:

$$\frac{7.30 - (83.6 \times 3.19) \times 100}{100 - 83.6} = 28.4 \text{ per cent}$$

CHECKING THE MILLER'S YIELD REPORT

The figures in Columns 4 and 5 may be used as a means of checking the yield report of the miller. These columns give the yields of flour as calculated from the pentosan and starch contents, respectively, by the use of Formula 1, which may be derived algebraically as follows:

Per cent Starch

Wheat..... 58.81

Offal..... 19.66

Flour..... 70.42

Let x = flour in wheatThen $1 - x$ = offal in wheat

$$\begin{aligned}
 70.42x + 19.66(1 - x) &= 58.81 \\
 70.42x + 19.66 - 19.66x &= 58.81 \\
 (70.42 - 19.66)x &= 58.81 - 19.66 \\
 100x &= \frac{(58.81 - 19.66)}{70.42 - 19.66} = 77.2 \text{ per cent}
 \end{aligned}$$

Column 3 gives the flour and offal yield of the wheat as reported by the miller. The figures of Columns 3, 4, and 5 should, therefore, agree. Where they are not concordant, this is probably due to changes in moisture content and to difficulty in obtaining strictly uniform samples. The latter is particularly true of the offal. Furthermore, a faulty technique was exercised in sampling the offal without preliminary grinding. It is very difficult to obtain a truly representative one-gram sample of a material like offal as it comes from the mill. Grinding to a consistency nearly as fine as flour should be regarded as one of the essential steps preliminary to its analysis.

METHODS OF DETERMINING THE FLOUR CONTENT OF WHEAT AND FLOUR MILL PRODUCTS

EXPERIMENTAL MILL—The experimental mill has come into extensive use for the purpose of determining the flour yield of wheat, a result which is also interpreted by some millers as the flour content. The method necessitates expensive equipment and thorough skill in its use, and even with these assets the results obtained are usually inaccurate and otherwise unsatisfactory. A wheat will not necessarily yield the same amount of flour when milled in an experimental mill as when milled on a commercial scale. The ordinary experimental mill will not make as complete an extraction, and the yield obtained can in no way be regarded as the flour content of the wheat. It is particularly difficult to obtain comparable results with a mechanical process of this kind, since slight variations in equipment and technique affect its results very materially.

CHEMICAL METHOD—It seems quite possible that a chemical method of determining the flour content of wheat will overcome most of the objections inherent in the experimental mill. In this method the starch contents of the wheat and of the flour it produces are used as a basis for estimating the flour content of the wheat or of any of its mill products. A sample of first middlings flour from the wheat to be tested is first obtained by milling a portion in an experimental mill far enough to bolt out the first middlings, or from the regular mill run. This stream rather than the finished flour is selected because it represents more nearly the pure and uncontaminated inner endosperm. The starch contents of this stream and of the wheat are determined, preferably by the diastase method.

The starch conversion factor given in Column 6 of Table V is obtained from the equation

$$\text{Conversion factor} = \frac{100}{\text{Per cent starch in flour stream}}$$

The starch content of wheat multiplied by this factor gives the flour content of the wheat. In case the flour content of a wheat is determined by the use of a factor obtained from the starch content of a commercial grade of flour, the result will be increased

according to the amount of offal that was present in that commercial flour, and will show how much flour of that particular composition the wheat contains.

Under certain conditions it may be advantageous to use this method in conjunction with the experimental mill. For instance, a knowledge of the milling qualities of a wheat may be desired. These may be determined by the experimental mill, and the flour content of the resulting offal may be determined by the chemical method. Then the flour yield as obtained by the mill plus the flour content of the offal will give the flour content of the wheat. A chemist who has acquired familiarity with this method may at times dispense with the starch determination in the flour, and estimate with a fair degree of accuracy the flour content of a wheat from its starch content, by multiplying this value by an assumed or arbitrary conversion factor.

Results obtained by this method are expressed in Columns 6 and 7. Column 6 contains the flour conversion factors obtained from the starch content of the several straight flours. Column 7 expresses the flour content of the wheats and their offals. As the starch conversion factors which were used in the calculation of these results were obtained from the starch contents of straight flours, the values expressed in Column 7 denote not the true endosperm content of the several wheats, but the endosperm plus the offal content with which these straight flours are contaminated. This fact does not depreciate the value of these results, for they show the amount of flour of that particular composition, quality, or purity which the wheat is theoretically capable of yielding.

THE CONSTANCY OF PENTOSANS IN BRAN

Column 8 gives the pentosan content of the flour-free wheat and flour-free offal as calculated by Formula 2. The constancy of these figures is significant. Variations in the ratios of bran to germ in these different wheats and offals are probably responsible for variations in their pentosan content. The bran contains most, if not all, of the pentosans, whereas the germ contains little, or possibly none. Hence, a high ratio of bran to germ would cause a correspondingly high pentosan content. As this is so nearly constant it may be possible to use it as the basis for a practical method of approximating the offal content of wheat. The average of the values in Column 8 is 28.5, and the conversion factor calculated therefrom is $100/28.5 = 3.51$. The difference between the pentosan content of wheat and that of its endosperm multiplied by this factor will give the offal content of the wheat. The pentosan content of pure inner endosperm is probably very constant. That of the several straight flours in Table IV is sufficiently so to warrant the use of their average, 3.13. The formula for calculating the offal content of wheat from its pentosan content will be:

$$\text{Offal} = (\text{Pentosan in wheat} - 3.13) \times 3.51$$

$$\text{Flour in wheat} = 100 - \text{offal in wheat}$$

Further work on this subject is now in progress.

MILL EFFICIENCY

The figures of Column 9 give the percentage efficiency of the several mills that furnished the samples.

These percentages are obtained by dividing the flour yields as reported by the mills by the flour contents of their wheats as expressed in Column 7, and multiplying the quotients by 100. Their efficiency is really lower than that indicated by the figures, which were calculated on the basis of the yield of flour which is appreciably contaminated with offal. The mills are given credit for this offal as though it were flour. This low efficiency is indicated in another way by the figures in Column 7 which express on a percentage basis the flour content of the several offals, which in one case runs as high as 37 per cent. The flour content of the offal in the first group, 27.9 per cent, is the lowest of all, and even in this case the loss is a serious one. This offal constituted 23.1 per cent of the wheat, according to the miller's own report. The flour in the offal, therefore, constituted 6.44 per cent of the wheat. The flour recovered by the miller was 76.5 per cent of the wheat. Out of every 100 lbs. of wheat containing 82.9 lbs. of flour, this miller recovered 76.5 lbs., and allowed the remaining 6.44 lbs. to go into the feed. Assuming that this flour sold for \$12 a barrel and his feed for \$60 a ton, he received \$0.06 a pound for the flour and \$0.03 a pound for the feed. The 6.44 lbs. which went into the feed brought him \$0.193, whereas it should have brought him \$0.386 if recovered as flour and sold as such. He lost, thereby, \$0.193 for every 100 lbs. of wheat milled. In the case of a 1000-bbl. mill this loss would approximate \$500 a day. Where the offal contained 37 per cent of flour the loss in a mill of the same size would amount to \$900 a day. These figures bring out in an emphatic manner the prevailing low efficiency of modern flour mills. A knowledge of this condition should stimulate efforts among millers to make a more complete recovery of flour.

SUMMARY

1—The inner endosperm or true flour-producing portion of the wheat kernel contains all the starch and only very small percentages of pentosans and fats.

2—The bran tissue including the aleurone layer contains a high percentage of pentosans, 5 or 6 per cent of fat, and no starch. The pentosan content of the offal tissue is fairly constant.

3—The embryo or germ and the aleurone layer contain a high percentage of fat, and no starch.

4—The amount of fat and pentosans in any grade of flour is a measure of the amount of offal (germ and bran) contained in that flour. The amount of starch contained in wheat or any mill product is a measure of the amount of inner endosperm and, therefore, of the amount of flour contained in that product.

5—The accuracy of the flour-yield determination of wheat as made by the ordinary experimental mill is dependent on two very important factors: the skill of the operator, and the completeness of the equipment. The methods outlined in this paper will not be subject to the errors inherent in a milling test and will constitute a more accurate means of estimating the exact flour content of any given wheat.

6—The determinations of pentosans or starch may be used as a control of the miller's yield reports.

7—These determinations and formulas may also be used for obtaining the milling efficiency on a percentage basis.

WELDING THERMOCOUPLES IN THE ELECTRIC ARC

By James C. McCullough

SEVERANCE CHEMICAL LABORATORY, OBERLIN COLLEGE, OBERLIN, O.

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The oxyacetylene flame usually employed for welding thermocouples is not always available, and with other gases it is difficult to secure the necessary heat without oxidizing the wires.

Base-metal thermocouples are easily and quickly welded in the electric arc, providing oxidation is prevented. A generous stream of illuminating gas is directed against the electric arc, and the twisted ends of the thermocouple wires are brought into the arc and fused together. Cooling for a few seconds in the gas prevents any trace of oxidation and no flux is required. Fifteen amperes alternating current has usually been employed, but for the larger sizes of wire a higher amperage is needed. The direct current arc is more efficient. The eyes of the operator must be protected by colored glasses.

THE WATER SUPPLY OF THE AMERICAN EXPEDITIONARY FORCES¹

By Edward Bartow

FORMERLY LIEUTENANT COLONEL, SANITARY CORPS, U. S. A., IN CHARGE OF WATER ANALYSIS LABORATORIES, A. E. F.

In the United States during the World War the construction and maintenance of water supplies for the Army was the duty of the Construction Division of the Quartermaster Corps; in the American Expeditionary Forces it was the duty of the Water Supply Service of the Engineer Corps. A regiment of water supply engineers, the 26th Engineers, was provided in the tables of organization of the A. E. F. This regiment was organized in the United States early in 1917, two of the companies were sent to France late in 1917, and the remainder in 1918. The

¹ Published by permission of the Surgeon General, U. S. Army.

Medical Department was to have control of the quality of water furnished, and detailed to each of the six companies of the 26th Engineers an officer of the Sanitary Corps and three men of the Medical Corps who should make water analyses under orders of the engineers. The Medical Department also detailed one Sanitary Corps officer to be sanitary inspector of water with each army division, under the orders of the chief sanitary officer of each division. Some of the officers of the Engineering and Medical Departments who were especially concerned with the quality of water felt that the division of authority indicated by