

respectively, were practically identical when the cooling or heating was sufficiently slow. The results of the freezing-point determinations are summarized in the accompanying table.

It will be seen that for thermometers of pure platinum, for which  $\delta = 1.50$ , calibrated on the basis of the Callendar equation, by observations in ice, steam, and sulphur, the temperature scale thus defined up to at least  $1100^{\circ}\text{C.}$  is in agreement with the generally accepted gas scale to well within the limits of accuracy with which that scale is known at the present time. For thermometers of impure platinum, it will be seen, that this equation no longer holds. A modified method of calibration, applicable to impure platinum, is discussed at length in the full paper, in which one other calibration temperature is used, such as the F. P. of Ag or of Cu, and in which  $\delta$  is not taken as a constant but as having different values ( $\delta = a + bt$ ) at different temperatures.

Thermometers of the purest obtainable palladium wire were also tried, for which  $\delta = 2.89$  and  $c = 0.00336$ . They do not satisfy the Callendar equation; for example, it leads to a value of  $1152^{\circ}\text{C.}$  for the F. P. of copper; up to  $600^{\circ}\text{C.}$ , however, the equation holds within  $1^{\circ}$ .

The effects of high temperatures on the constants of platinum thermometers is, in general, to reduce the value of  $R_0$  and increase F. I., *i. e.*, the effect is as if the platinum were purified by the loss by evaporation of impurities, such as iridium. When the wire is very pure to begin with  $R_0$  generally increases slightly and  $c$  decreases, due to the combined effects of strains caused by thickening of the mica frame and of contamination of the wire. The changes are much less for pure than for impure platinum. With thermometers of pure platinum and not too fine wire, wound on the mica frame as free from strains as possible, the changes in  $R_0$  after some ten determinations of the freezing points of silver and copper (corresponding to about 25 hours use) were only a few tenths of a degree. For about equal use, one of the thermometers of impure platinum ( $\delta = 1.57$ ) and very fine wire (0.05 mm.) showed a decrease of  $R_0$  corresponding to  $6.5^{\circ}$ . Thermometers of pure platinum and heavy wire (0.6 mm.) without the usual mica supporting frame showed unusually small changes in  $R_0$  even after several heatings for some hours each at  $1250^{\circ}\text{C.}$ , changes equivalent to only a few tenths of a degree.

The freezing point of the silver-copper eutectic ( $779.2^{\circ}$ ) is a convenient fixed point in the long interval of over  $300^{\circ}$  between the freezing points of antimony and silver.

Pt, Pt-Rh and Pt, Pt-Ir thermocouples, calibrated in terms of the equation  $e = a + bt + ct^2$  at three of the freezing points as found with thermometers of pure platinum (*e. g.*, Zn, Sb, Cu or Zn, Ag-Cu, Cu), were found to be in agreement with one another and with the scale of the platinum thermometer at intermediate temperatures to within  $0.3^{\circ}$ .

*Work under Way.*—In addition to the work now under way which has already been referred to, encouraging progress has been made in the following investigations:

(a) The determination of the heats of combustion of industrially important gases, using several different bomb calorimeters, different methods of calorimetry, calorimetric platinum resistance thermometers, and electrical standardization of bombs. The work was undertaken in order that the Bureau might prepare standard tables of the calorific values of gases for the use of the gas industries. In this investigation will also be included an examination of the leading types of gas calorimeters used in the industries in this country and abroad, with a view to determining the order of accuracy attainable with the various instruments, their limitations, and the precautions that must be observed in their use under various conditions.

(b) An intercomparison of the various viscosimeters used

in this country and abroad for the examination of the viscosities of oils, and their comparison with absolute viscosimeters, to enable engineers to intercompare results found with different instruments. This work was undertaken to assist the International Petroleum Congress and the various engineering societies who are endeavoring to bring about some uniformity and some improvement in the present unsatisfactory status of oil testing.

(c) The determination of the emissivities of substances at high temperatures, to which optical pyrometers are being applied in the industries (*e. g.*, steels, bronzes, etc., in both molten and solid conditions, carbon, porcelain, glass, etc.), with a view to determining the departure of the radiation from these substances from black body radiation and thus to enable the necessary corrections to be applied to the indications of optical and total radiation pyrometers to get the true temperature of the material under observation.

(d) The determination of the melting points of the highly refractory elements and materials, for which little or no data are at present available.

(e) The intercomparison of the temperature scales defined by the Wien-Planck and Stefan-Boltzmann radiation laws up to the highest attainable temperature. This work must serve for the establishment of the high temperature scale above the range of the gas thermometer.

(f) The establishment of the temperature scale in the interval  $100^{\circ}$  to  $500^{\circ}\text{C.}$  with the highest accuracy, in a way very similar to that already described for the standard scale in the interval  $0^{\circ}$  to  $100^{\circ}\text{C.}$

*Circulars of Information.*—Two circulars have thus far been issued by the Heat Division, *viz.*:

No. 7. Pyrometer Testing and Heat Measurements (2nd edition).

No. 8. Testing of Thermometers.

Circular No. 7 contains information relating to the high temperature scale, the methods of standardizing and important precautions that should be observed in the use of thermoelectric, electrical resistance, optical and radiation pyrometers, the various heat tests the Bureau is prepared to undertake, and tables of fees charged for testing.

Circular No. 8 contains information relating to the thermal properties of glasses, the fundamental principles of mercurial thermometry, the construction and methods of use of thermometers, low temperature thermometers, and tables of fees for testing thermometers.

A circular containing complete specifications for a set of high-grade mercurial thermometers, suitable for laboratory standards, for measurements in the interval  $-35^{\circ}$  to  $525^{\circ}\text{C.}$ , is in preparation.

*Furnishing Information.*—One of the functions of the Bureau is to furnish to engineers and technical men such information as may be in our possession, relating to physical constants, the properties of materials, methods of measurements, etc. To this end correspondence is invited. Our laboratories are always open to those interested in the various lines of work in progress or in search of such information as we may have and which might be of assistance in promoting the application of scientific methods in the industries.

## ADDRESSES.

### THE CHEMIST'S PLACE IN INDUSTRY.

BY ARTHUR D. LITTLE.

Chairman Division of Industrial Chemists and Chemical Engineers.

The industrial chemist who believes that "life is not made for science but science for the development of life" takes no narrow view of what life is or what its best development must

mean. He recognizes that there is a hunger of the mind and a hunger of the spirit no less than a hunger of the body, and that only in such measure as all are satisfied does life become worth living and result in growth. He is therefore quick to render full meed of honor and appreciation to those workers in his own or other branches of science who pursue the truth for the truth's sake. He believes with them that the truth alone shall make us free. He resents however and denies the imputation that he is any less valiant for the truth than they, merely because the particular truth he seeks is one which has an obvious and immediate application to "the development of life." Especially does he repudiate the pedantry which as Thomson puts it "would regard science as a 'preserve' for intellectual sportsmen."

The industrial chemist asks no better definition of science than that contained in Huxley's famous dictum: "Science is organized common sense," and he believes with Sir Michael Foster that "Men of science are common men drilled in common sense." Where then shall common sense find better field for exercise and adequate expression than in those industrial activities on which our daily life depends? To this field then the industrial chemist devotes himself without apology, being well aware that before the hunger of the spirit or the hunger of the mind can be appeased, the hunger of the bodies moving by millions through the world must first be satisfied.

In its effort to satisfy this hunger modern industry has developed a complexity of organization, a magnitude of operation, a scale of expenditure and a drive and pressure of production far beyond anything which the world has seen before. Men and machines have alike been speeded up, worn out and cast aside. The march of progress has been over a continuous battlefield upon which the old was ever struggling with the new, new methods of organization, new principles of practice, new processes of production, new conditions of supply, new relations between man and his work. Accompanying it all in our own country at least has been a riot of waste lighting up the background with the flame from forest fires, burning oil wells, wasted gas and beehive coke ovens; cumbering the field with forest litter, piles of culm and slag, scrapped machinery and abandoned plant; poisoning our water courses with wastes which bore away a profit. With us through all our recent industrial development the watchword has been "increased production." To that we have sacrificed our resources, our future and the well-rounded development of our own lives. Our reward, inadequate though it is, has come in a producing capacity beyond all precedent and in costs of production so low as to be ruinous if continued long enough. We have succeeded because of a supply which once seemed limitless of the cheapest raw material the world has known. The conditions and practice of the past may serve for the development and exploitation of a new country but they involve wastes so stupendous as to spell bankruptcy for that country at maturity unless changed.

Evidence is everywhere at hand that the day of cheap raw material is passing if indeed it is not already past. To those who read the signs the watchword of the future is even now clearly outlined; it is no longer "increased production" but "increased efficiency in production."

It is into a world thus constituted that the chemist who elects to apply the organized common sense of science to industrial problems finds himself projected. It is a world in which great and avoidable wastes are everywhere existent, but a world which nevertheless is fostering and encouraging a growing sentiment for conservation. It is a world, used to progress at any cost, awakening to the value of the scientific method as an aid to progress and already under a heavy burden of obligation to chemistry for the achievements of the past. Into this world he comes with his activities still unfortunately shaded in many minds by the penumbra of the mystery which surrounded the old alchemists. Small wonder that he insists that the science

to which he owns allegiance is nothing more than organized common sense, the common sense which would check waste, increase efficiency, get the utmost possible return from all expenditure whether of capital, material or effort.

In justification of his claim to capacity in practical affairs the chemist can point to a brilliant record of accomplishment—a record of colossal industries which had their small beginnings in his laboratory, of waste places made to blossom, of mountains of discarded refuse turned to profitable uses, of industrial revolutions initiated by him, even a record of prestige and power brought to nations by his discoveries. Nevertheless it remains true, as the chemist himself will be the first to acknowledge that the results accomplished in the past have in large measure been independent of his training and that in his relation to present-day industry he is handicapped in many ways. At the outset of his career he is confronted with such multiplicity of detail in the province of knowledge he has chosen for his own as to leave little time for the studies and accomplishments which make for breadth of culture and a wide outlook upon life. He is taught to deal with things only to find that progress is often determined by an ability to deal with men. He spends years in acquiring the difficult technique of chemical analysis and when facility is at last attained, sometimes forgets that analysis is after all only a means of securing data upon which to base subsequent action and that chemists who make it an end soon reach that end and stay there. His work is confining. It is largely carried forward in the seclusion of the laboratory and often under conditions which impose secrecy. It is not then surprising if through lack of opportunity the chemist sometimes fails to acquire that knowledge of affairs which is an essential prerequisite for any commanding influence and without which the difficulties of taking one's proper place in the world of men are enormously enhanced. Moreover, as the result of industrial conditions, the limitations of his training, and his own lack of capital, the chemist who devotes himself to applied science almost invariably does so as an employee. He is apt through want of initiative or under the compelling force of circumstance to remain an employee, whereas he should far more often seek out and utilize the opportunity of directing capital along lines of independent enterprise. Most of all, perhaps, the industrial chemist of the past has been handicapped by the limitations of his knowledge, by his inability to translate the findings of the laboratory into terms of actual practice. He has been content too often to merely take the pulse and temperature of the patient and leave to others the diagnosis and the cure. Particularly has the industrial chemist been weak upon the engineering side, in the adaptation of means and ends upon the large commercial scale.

For these reasons and to this extent he has failed and often still is failing to "deliver the goods." His failure reacts directly upon himself and indirectly upon the whole profession. The making of chemical analyses is ceasing to involve the exercise of a profession. It has almost become a trade. In Pittsburg Hungarian boys whose normal earning power is \$7.00 a week, are quickly trained to make from twenty to thirty silicon determinations a day. Flue gases are now analyzed every ten minutes and the results plotted in a curve by ingenious and accurate machines.

Some chemists see in these developments of the purely manipulative side of chemical work the beginning of the end for the profession. Nothing could be further from the truth. When Hungarian boys make silicon determinations and machines record the carbonic acid content of flue gas, the chemist who is worthy of the name is not displaced, he is set free, free to devote himself to larger problems and equipped with more comprehensive data for their attack. Let us then while fully recognizing the dignity of analytical work, never forget that it is after all only a means to an end, and that it derives its dignity from

the use to which it is put. There is no dignity in analyzing a water sample brought in by somebody in a four-ounce bottle smelling strongly of vanilla.

That the conditions of which some complain have long been impending is proved by the fact that twenty years and more ago no less a chemist than Sir William Crookes felt himself impelled to publish in the columns of *The Chemical News* frequent warnings to students in chemistry in which he pointed out the lack of recognition and the meager monetary rewards awaiting them. He specifically and with dire emphasis refers to one gentleman behind whose name trailed the letters M.A., F.C.S., F.I.C., who was called upon to determine from April to November, both inclusive, butter fat and total solids in thirty-six samples a week for a total honorarium, it could hardly be called a payment, of £20 or something less than 4d. a sample. One ought to be sorry for the gentleman and appalled at the decadence of British science, but somehow one cannot help feeling that the man who made the analyses at such a price received all the work was worth and that if he and others in his case had busied themselves about more important matters the outlook for chemistry in England would have been more encouraging.

But this is enough and more than enough of the pessimistic view of the chemist's place in industry. Let us turn to a consideration of the opportunity which really lies before him.

The first object of the industrial chemist should be that of increasing industrial efficiency. What are the factors upon which industrial efficiency depends, and to what extent can he hope to influence them? The principal factors are:

Cheap raw material.

Cheap power.

Efficient labor.

The control of processes.

The elimination of wastes.

The maintenance of standard in product.

Cheap transportation.

To an audience of chemists it is only necessary to state these factors in order to indicate at once the commanding influence which members of our profession should exert in case of each of them. That we have sometimes failed to make this influence felt, has been from other causes than lack of opportunity. A brief analysis must make this clear.

It is within the power of the chemist to determine the selection of the most efficient and therefore the cheapest raw material, to control the quality of that material in many instances through specifications, inspections, analyses and physical tests, to open up new sources of supply for the same or an alternative material. In the present state of industry it is easily possible for the chemist to institute savings amounting on single items of material to tens and even to hundreds of thousands of dollars or more a year.

Chemists sometimes forget that their science deals with energy no less than matter and that in fact chemistry as a science began with the recognition of the principles, materials and products of combustion. They have allowed the mechanical engineer to usurp many things which properly come much more directly within their own province. The combustion of coal is a typical chemical process. The selection of the most efficient coal and the determination of the conditions necessary for its most efficient combustion are essentially chemical problems. Chemical problems also are those arising in the manufacture of producer and illuminating gas, their utilization in gas engines, the development of power from the waste gases of the blast furnace, the adaptation of conditions to the proper handling and burning of peat, lignite and waste coal, the thermometric exploration of coal piles to forestall spontaneous combustion, smoke abatement, the control and improvement of fireroom conditions by draft regulation, flue gas analysis, temperature measurements and even the placing of firemen on the bonus basis. Taking power plant practice

and the conditions of coal purchase as they stand, the properly equipped chemist should be able to increase the efficiency of power production from five to thirty per cent.

The analysis of boiler compounds as an end in itself presents little to excite enthusiasm, but when such analyses are made the means of saving \$3600 a year in the power plants of a single company they take on a new and larger aspect, not only in the mind of the chemist but in the mind of the chemist's client.

The chemist who attacks the problems of power production will not hesitate to go outside the laboratory and take his property wherever he finds it. He will conduct boiler and engine tests, study the efficiency of grates and stokers, familiarize himself with the marvelous promise of the low-pressure turbine as an agent in efficient power production. While straining every resource of his science to produce steam economically by the combustion of coal, is it common sense for the chemist to stop there in ignorance of the fact that the efficiency of that steam can be increased at once from 25 to 100 per cent. by coupling a low-pressure turbine to the exhaust?

The distribution of power supplies problems no less directly within the province of the industrial chemist. He may begin with the analysis of lubricating oils. He proves his own inefficiency if he stops there. He must inform himself regarding the market prices of oils used elsewhere for similar service, the adaptability of the oils in question to application to the bearing by soaked waste, sight feeds, or gravity cups. He must be prepared to interpret his analysis in terms of practice and to follow the oil through the plant in order to prescribe conditions which shall keep down waste. There are few plants in which the industrial chemist working along these legitimate lines cannot save from 20 to 60 per cent. of the entire lubrication account, while the oil analyst has to his credit merely a few figures which his client probably fails to understand.

The efficiency and life of bearing metals varies over an extraordinarily wide range. Some are merely the refuse from type foundries, others are so carefully adapted in their composition to the requirements of particular service as to show an efficiency fifteen times or more as great as that of inferior materials. Here again the mere analysis means little, the practical question is "Which is the more efficient metal under the conditions imposed by practice?"

Much additional might be said regarding the opportunity before the chemist when any material concerned in power transmission is the subject of his study, whether it be leather, rubber or canvas belting, belt dressing, insulating material, trolley wire, trolley ears or trolley wheels. In every case it is within his power to create new standards of efficiency.

Similarly the industrial chemist has a large control over the efficiency of labor. He may increase this efficiency, that is, the output of the individual laborer, by supplying more efficient processes as Bessemer did in case of steel, Tennant in case of bleaching, or Le Blanc and Solvay in the manufacture of alkali. He may raise the efficiency of the laborer through education as when firemen are instructed in proper firing methods or when cooks in the sulphite pulp mill are given boiling schedules; in one instance within our knowledge such schedules raised the efficiency not of the cooks alone but of the entire plant as well, over 50 per cent.

Nowhere has the industrial chemist greater scope for the effective exercise of his trained and organized common sense than in the control of processes and the elimination of wastes and nowhere are the results he has already obtained more valuable. Their influence upon productive industry has been dramatic and profound. One need not say to chemists that the whole art of modern steel-making is under the strictest chemical control, or quote Carnegie to the effect that it has been revolutionized thereby. No industry affords a better example of the value of such control or furnishes more striking

instances of the profitable utilization of wastes. The conversion of slag to cement and fertilizer, the development of 10,000 horse power from the waste gases of a single furnace, are but steps in the development which will soon make pig iron the by-product of the furnace which derives its chief revenue from the waste of yesterday. With the open-hearth furnace still utilizing less than 10 per cent. of the energy of its fuel, let no chemist think the door of opportunity has closed.

Two factors of the first importance in their bearing upon industrial efficiency remain to be considered. They are:

The maintenance of standard in product.

Cheap transportation.

To mention them in this assembly is to bring before the minds of almost every one of us the endearing personality, the noble character and the splendid, comprehensive service of the friend we have just lost, Dr. Charles B. Dudley. Wherever his name is known, wherever material is bought on specifications which protect alike with scrupulous fairness the interest of seller and consumer, wherever standardized equipment safeguards life and property in railway travel, there is every reason but no need to speak in eulogy of what the chemist has accomplished in these regards.

From whichever viewpoint the relation of the chemist to the problems of production is studied it becomes clear that to take his proper place in the world of industry he must learn to know not only matter but material, and material under the strains and stresses of actual practice and with the limitations which commercial conditions impose. To the refinements of the laboratory he must add, as he is already adding in constantly increasing measure, the broader touch and larger method of the engineer; and finally, he must recognize that to reach his highest plane of service he must study men as well as things.

## NOTES AND CORRESPONDENCE.

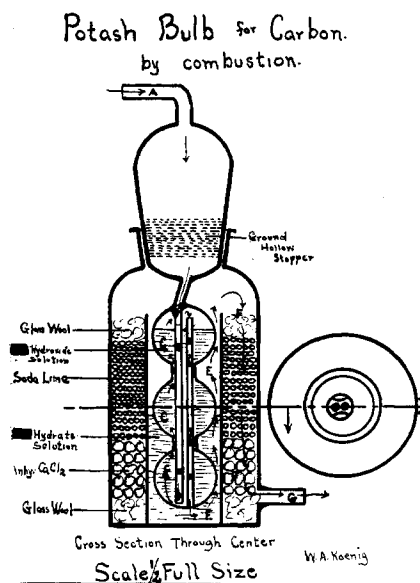
### POTASH BULB FOR CARBON BY COMBUSTION.

The Mohr, Winklers-Liebig and all the potash bulbs thus far invented and in present use are of such complicated open structure that it is extremely difficult to properly clean them before weighing. With the Liebig this is less true than with the others, but it is necessary to weigh a separate piece of apparatus along

with it. We believe that this piece of apparatus overcomes these difficulties and is as efficient if not more so than any that have preceded it. Its weight filled with the chemicals is from 60 to 75 grams.

The course which the gas takes is shown by the arrows. Entering at A it passes through the hollow stopper and tube B B into the bulbs C C C which contain 1.3 caustic potash. It ascends to the top bulb and goes down through the tube D D, out into the cup E E, also

half-filled with 1.3 caustic potash. Rising to the top of E E it goes out into the bottle F F, passes down through soda lime and anhydrous calcium chloride and finally out at G.



One of these bulbs has been made by an expert glass-blower. It has been tested and gives results which do not vary over 0.0005 gram.

N. A. KOENIG.

### THE DETERMINATION OF MOISTURE BY DISTILLATION.

As is well known it is frequently impossible to determine with accuracy the moisture in substances by simply drying in a steam, water or hot air oven because of volatility of some ingredients or the oxidation of some constituents of the sample. Even when a current of carbon dioxide is used, it does not in all cases overcome the difficulties.

In the case of the determination of water in tars, a method of distillation has been in general use for some time. Light hydrocarbons such as toluene and xylene have been added to such tars to aid in carrying over the water. In the case of tars, because of their particularly viscid character and the danger of bumping and frothing special distilling arrangements have also been advised.<sup>1</sup>

Other suggestions for the determination of water by distillation have been made by G. Testori,<sup>2</sup> who determined the water in molasses by distilling 50 grams with 200 cc. of turpentine and caught the condensed water in a graduated cylinder. He claimed this procedure to be more accurate than ordinary oven-drying.

J. Marcusson<sup>3</sup> proposed determining water in oils, fats, soaps, resins, etc., by distillation with an immiscible liquid. Water-saturated xylene was used as the liquid to carry over the water in distillation. The water was caught in a 100 cc. graduate which would not insure very great accuracy in the operation.

The estimation of moisture in creosote oil by Arthur L. Dean<sup>4</sup> is based upon the work of Marcusson, but provides for more accurate measurements of the condensed waters.

Graefe<sup>5</sup> also determined the moisture in lignite by distillation with naphtha.

The object of the writer in carrying out his experiments upon the determination of water in various substances by distillation was to see if a general method of procedure could be found for the determination water in substances for which an oven test is not accurate or is too slow in giving a constant weight.

The writer for a number of years past has made moisture tests by distillation on samples of tar, crude camphor, hide grease and oils in which water was either suspended or emulsified and had tried at different times toluene, xylene (dry- and water-saturated), unfractionated coal tar solvent and benzene. It was thought best to extend some of the more recent experiments so as to make the work more general in character.

*Description of Method.*—The receiver selected was similar to that adopted by Dean and consisted of a tube of glass of about 5/16 inch inside diameter and graduated in cubic centimeters and tenths. Ten cc. are marked off and should be about 10 inches lineally on the tube or 1 cc. per inch. At a little above the 10 cc. mark, the tube is flared out funnel- or bulb-shaped (with open top) sufficiently large to hold 250 cc.; it is best not to have a stop-cock at the bottom, a device that was tried by the writer but found to be liable to leakage.

Sufficient substance is very carefully sampled and quickly covered with 200 to 300 cc. of benzene in an Erlenmeyer flask holding 16 ounces (500 cc.). The amount taken will generally be 25 or 50 grams depending upon the moisture content.

The water line on distillation should come in the upper half of the graduations if possible. The flask is then connected to a

<sup>1</sup> H. W. Jayne, *Jour. Amer. Chem. Soc.*, **25**, 814 (1903). E. Senger, *Jour. fur Gasbeleuchtung*, **45**, 841; *Jour. Soc. Chem. Ind.*, **1902**, 1475.

<sup>2</sup> *Staz. Sperim. Agara. Ital.*, **37**, 366-9; *Chem. Central.*, **1904-2**, 562-3.

<sup>3</sup> *Mitt. K. Materialprüfungsamt.*, **23**, 58 (1905).

<sup>4</sup> U. S. Dept. Agr. Forest Service Cir., **134** (1908).

<sup>5</sup> Graefe-Braumkohle, 1905.