

with every known appliance for the required operations.

The two most eminent of the chemists here are Otto N. Witt, the coal tar dye authority, and Liebermann, the pyridine chemist. Witt was teaching porcelain production, and the building is only a quarter of a mile from the Royal Berlin Porcelain Works. Prof. Witt was one of the two German special commissioners at the World's Fair, and he has published a most entertaining report, embodying also an estimate of the chemical manufacturing probabilities in America, and a high tribute to the chemical achievements of American metallurgy. Liebreich in pharmacology, and Kossel in physiological chemistry, are authorities of great interest. Tiemann on the chemistry of perfumes, Rimbach on optical methods for chemical ends, Traube on chemical crystallography, Freund on the chemistry of foods—these are but a few of the many chemical specialists whose classes are open to university students.

THE GERMAN CHEMICAL SOCIETY.

The monthly meetings of the German Chemical Society are held in Prof. Fischer's lecture room. Here it was that A. W. Hofmann presided from the very organization of the society until his death. The attendance is a scattering one of thirty to fifty out of a large membership.

By a new and improved arrangement, each paper is presented in oral abstract by an appointed reader, if the author be not present himself. The discussions at the July meeting were prompt, brief, and to the point, and fifteen or sixteen subjects were disposed of in one and one-half hours.

LEIPSIK LABORATORIES.

At Leipzig the First Chemical Laboratory, built in the last of the sixties, conducts a great variety of advanced work, under a good corps of teachers, with Wislicenus as director. The equipment is good; there are sufficient smaller rooms for classification of methods, and there is a constant lookout for improvements; but there is neither elegance nor a very strict maintenance of neatness. Wislicenus, who was rector (presiding officer) of the university last year, is a model of helpfulness to visitors, and his lectures are the perfection of good teaching and masterly grace.

The Second Chemical Laboratory, that of Ostwald, the author and editor in physical chemistry, has not yet a separate building, but is quartered in half a dozen smaller rooms of the Agricultural building. Ostwald gives, besides other lectures, a free public course of lectures on the forces once a week. The majority of the American chemical students at Leipzig, when I was there, were from the Johns Hopkins. They used the one laboratory or the other, just as they would use one or another branch of the same laboratory.

THE TEACHERS AT MUNICH.

At Munich the chemical laboratory, Von Baeyer's, is on Arcisstrasse, with neighboring botanical grounds; and though not new, it is a commodious building, well provided for a large amount of the best work. It cherishes the working places of Liebig, who was there for the last twenty years of his life (until 1873). The chief associates of Baeyer are Pechmann and Kruess* in analytical and inorganic chemistry, Koenigs and Thiele in organic. Prof. Hilser, the pharmaceutical chemist, is at Munich. I saw Mr. Sherman, formerly of Ann Arbor, and Mr. Faust, formerly at Baltimore, both at work as chemical students. I heard Prof. Baeyer and Dr. Kruess lecture. Baeyer's lectures aim at placing the foundations of his subject, that is, chiefly at clearly setting forth the first principles of chemistry, and are given plainly without great illustration. The "arbeiten" in Munich are mostly directed by the associate professors. I am informed that the required preparation for "arbeiten" is of a high standard.

NUMBER OF STUDENTS AT THE UNIVERSITIES.

The largest three of the German universities compare as follows:

Berlin, total 4,025, in chemistry as leading study 205, equal to 5 per cent. of all.

Munich, total 3,464, in chemistry as leading study 140, equal to 4.19 per cent. of all.

Leipzig, total 3,067, in chemistry as leading study 114, equal to 3.7 per cent. of all.

At Heidelberg the new laboratory, to which I have already referred, is spacious, orderly and admirably equipped. The old part, however, is still used throughout, and its interior has become very shabby. Prof. Bunsen, now 83 years of age, who has given personal instruction to great numbers of men now eminent in chemistry in all parts of the world, retired five years ago.

VICTOR MEYER.

Victor Meyer, the present director of the laboratory, is probably the most attractive chemical personality in Germany, both for the direction of arbeiten and for his lectures, which are delivered six times a week, at 8 a. m. At the lecture table he is clear and fluent, rapid and orderly in experimentation; and without pausing for emphasis, he gives all the synthetic reactions in unbroken succession, covering the board over and over again with a rich profusion of delineations. Nevertheless, he holds the close attention of the beginners. There are as many chemical students from England and America in Heidelberg as in any two other German universities together.

I visited the Freiberg Mining School, in Saxony, and the analytical laboratory of Fresenius, at Wiesbaden, both of which are well known to chemists. Both these institutions show that important chemical work can be done with simple apparatus on rough tables. At Freiberg there is a considerable American colony.

EXPERIMENTAL WORK BY MANUFACTURERS.

Before closing this cursory account of the laboratories of chemistry in the German empire, I must make mention of the experimental laboratories of the great manufacturing works. These also are places of research in part for publication. I had full oppor-

tunities in four of these works: 1, the "Badische Anilin und Soda Fabrik," at Ludwigshafen, with its 4,000 workmen; 2, the Color Works at Hoescht, 3,000 hands; 3, the United Factories of Zimmer & Co., for cinchona alkaloids at Frankfurt; and 4, the chemical works of Merck, at Darmstadt. The exhibits of several of these works were included in the great monument of synthetic chemistry, made by German universities, in the educational department at the Chicago Exhibition.

The most appreciative mutual relations exist between the chemical industries of Germany on the one hand and her university chemical laboratories on the other hand. In fact, the liberality of the manufacturers is not confined to the universities of their own country, as we have reason to know, having lately received gifts of large collections from two of the works just named, with all charges of transportation paid to Ann Arbor.

In the way of investigation the German universities are of inestimable value to learning. In opportunity for the highest study they are scarcely equaled.

It has been a great privilege to me to see even but a little of the chief laboratories of Europe, and I regret that my means of description do not enable me more fully to share this privilege with my readers.

THE CHEMISTRY OF THE SIEMENS FURNACE.*

By A. M. DICK and C. S. PADLEY.

In submitting this short paper on the chemistry of the Siemens furnace it is not our intention to go deeply into detail, but rather to treat the subject in a more or less elementary form, confining ourselves to some of the chief reactions already well known to metallurgists.

The Siemens regenerative furnace is constructed on the open hearth principle, and may have either a basic or an acid lining, but, as basic work is of little moment in Scotland, we confine our remarks to the acid process. Though not coming strictly under the title of this paper, a short description of the furnace may here be introduced with advantage. The combustion chamber, or body of the furnace, from the charging floor level, is constructed of silica bricks, which, from their refractory nature, are capable of withstanding intense heat without softening. This part of the furnace, together with the bottom or hearth, which is also composed of siliceous material, is strongly braced together by suitable binders to resist the expansion, which is considerable, owing to the high temperature employed in the Siemens furnace. The hearth is supported by steel girders, beneath which are the four regenerative chambers, two being for gas and two for air. These regenerative chambers are almost filled with firebricks placed in alternate layers at right angles to each other, sufficient space being left for the free passage of the gas and air, which enter the furnace through suitable inlets, technically termed ports, thorough combustion being obtained by placing the air ports over those provided for the gas. After combustion on the furnace hearth the waste gases, before entering the chimney flue, pass through similar ports and down through the regenerators at the opposite end of the furnace, raising the bricks contained in the latter to a high temperature. By means of suitable valves, at intervals of about thirty minutes, the direction of the current is reversed, and the heat, already stored up in the chequered brickwork, is communicated to the incoming gases. This is, of course, the principle of the regenerative furnace, and the ease with which a great heat may be maintained in the furnace, with a comparatively small expenditure of fuel, has proved of great value to the steel maker. As already stated, the fuel used in the Siemens furnace is gas, and is obtained by the passage of air, or a mixture of air and steam, over a stratum of red hot fuel. The apparatus in which the gas is made is known as the gas producer, and exists in many types and forms. For our present purpose we may classify them as of two types, viz., those which have an open grate and depend on cooling tubes for their draught, and those which are worked with a close grate, and are supplied with air by means of steam blowers, or other means of induced draught. The composition of gas from a steam blown fire varies more than that from the open grate type, but the following may be taken as an average analysis of each:

	Open grate. Per cent.	Steam blown. Per cent.
Carbon dioxide, CO ₂	3.0	6.0
Carbon monoxide, CO	29.0	23.0
Hydrogen, H ₂	8.0	18.0
Marsh gas, CH ₄	3.0	3.0
Nitrogen, N	57.0	50.0
	100.0	100.0
Combustible volume	40	44

As will be seen from the analysis, the total combustible volume is slightly larger in the steam blown fire, the amount of hydrogen being specially noticeable. The nitrogen is correspondingly lower, but there is generally a higher percentage of carbon dioxide. Perhaps the chief advantage of the steam blown fire lies in the fact that inferior fuel, such as dross, can be used, and that, in shoveling out the ashes, there is comparatively little waste of unburnt char or coke. In the case of open grate producers the gases are conveyed to the main gas culvert by overhead cooling tubes, while those from the more modern close grate type are conveyed through underground brick flues and enter the furnace as already described. The hearth, or bath, of the furnace, on which the charge is worked, is composed of a mixture of a highly refractory and a more fusible sand. This mixture is applied in thin layers, and at the temperature employed becomes sintered into a cohesive mass, sufficiently hard to withstand the necessary amount of wear and tear. Unlike the bottom of a puddling furnace, which forms an active agent in removing the metalloids,

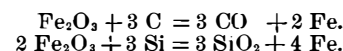
carbon and silicon, the hearth or bottom of a Siemens steel furnace (either basic or acid) remains inert, and has no chemical action on the charge. The charge, or material from which the steel is to be made, consists of hematite pig iron and steel scrap, the proportions being largely influenced by the amount of scrap available. A very common practice in this country is to use about 75 per cent. pig and 25 per cent. scrap. A pig and scrap charge, suitable for working in the Siemens furnace, is of the following composition, though manganese varies very much in different brands of iron:

	Hematite Fig.	Steel Scrap.	Initial Charge.
Carbon (graphite)	3.500	3.750	2.620
" (combined)	0.250	0.170	0.230
Silicon	2.200	0.025	1.660
Sulphur	0.043	0.045	0.042
Phosphorus	0.043	0.045	0.042
Manganese	0.500	0.500	0.500
Iron (by difference) ..	93.464	99.215	94.906
	100.000	100.000	100.000

From these analyses it will be seen that carbon, silicon and manganese play the leading part in the reactions about to be described, it being necessary that these elements be almost totally eliminated before the metal can be described as steel. As there is no reduction of sulphur and phosphorus during the working of the charge, it is imperative that the percentage of these elements, in the initial charge, does not exceed that permissible in the finished steel. A high percentage of silicon in the initial charge retards the working, as a greater quantity of ore is required to effect its oxidation. It is therefore best kept within reasonable bounds, though, as silicon decreases in pig iron, sulphur occasionally shows a tendency to become unreasonably high. In the manufacture of mild steel, the removal of the oxidizable elements is effected by the use of iron ore reasonably free from impurities and preferably of a fairly "lumpy" nature. The well-known Somerstro ore, which has been found very satisfactory, is of the following composition:

Fe ₂ O ₃	77.500
MnO ₂	1.500
Al ₂ O ₃	1.200
CaO	4.820
MgO	0.320
SiO ₂	5.250
S	trace
P ₂ O ₅	0.032
CO ₂	4.280
H ₂ O (combined)	5.020
	99.922
Metallic iron	54.25

When the charge is thoroughly melted, it is necessary to add iron ore to effect the oxidation of carbon and silicon. The reactions which take place are as follows:



The carbon escapes in the form of carbonic oxide gas, and the silicon, which is oxidized to silica, combines with a small quantity of oxide of iron with the formation of a fluid slag. This slag consists mainly of silicate of iron with a large excess of silica and small quantities of manganoous and calcic silicates, a usual composition, before adding ferro-manganese, being:

FeO	23.59
MnO	3.82
CaO	4.16
MgO	0.21
SiO ₂	68.02
	99.80

The silica and ferrous silicate in the slag are derived from three sources: (1) From the oxidation of the silica in the charge; (2) from the silica originally contained in the ore; (3) from the wear and tear of the furnace bottom. This slag, though of no commercial value, fulfills a useful function in protecting the metallic iron of the charge from the oxidizing effects of the furnace atmosphere, and subsequently prevents the metal in the ladle from chilling during casting. The operation in the furnace may be divided into four stages:

1. Melting. 2. Going on boil. 3. Boiling. 4. Steel.

The accompanying table will show at a glance the changes which take place.

	Melted.	Going on boil.			Boiling.			Steel.		
	1	2	3	4	5	6	7	8		
Carbon	3.19	3.19	3.18	2.83	1.51	0.53	0.20	0.14		
Silicon	2.25	2.0	1.5	1.09	0.046	0.035	0.03	0.03		
Manganese	0.30	0.25	0.21	0.14	0.09	trc	trc	trc		

Sample No. 1 was got immediately the charge was melted, and the subsequent samples at intervals of one hour afterward. In actual practice, a sample drawn from the bath immediately on becoming molten was of the composition shown in column No. 1 of the above table. This represents the composition of the charge. In order to make the reactions more distinct, we selected a charge in which only 10 per cent. of scrap was used, hence the carbon and silicon are slightly higher than those in the ideal charge already given. This circumstance in no way impairs the usefulness of the table. Columns Nos. 2 and 3 represent the second, or "going on boil" stage. Though a certain amount of ore has been added, the bath has, up to this point, remained comparatively quiescent. It is evident, however, from the decrease of silicon and manganese, that some work has already been accomplished. It will be noticed that the carbon has not been similarly affected, because, at this stage, the affinity of silicon and manganese for oxygen is greater than that of carbon. In the third, or "boiling" stage the surface of the bath presents an aspect of brisk ebullition; carbon monoxide is freely evolved from all parts, and can be seen burning with its characteristic blue flame. The changes during boiling are shown in columns 4, 5 and 6. We find that the silicon has been

* The death of Prof. Kruess has been announced since the above was written.

* A paper read before the West of Scotland Iron and Steel Institute and published in the Colliery Guardian.

greatly reduced, the manganese has almost disappeared, and the carbon is being vigorously attacked. At the end of this stage, the metal is ready for being tapped, if required, for such purposes as hard wire, rails, hard billets, etc. If required for boiler plate, ship plate, or other mild quality, the operation will take some two hours longer. As the charge under notice was intended for mild steel, we had the opportunity of getting two more samples at further intervals of one hour, and these bring us to the last two columns of our table. The only alteration now is in carbon, which becomes difficult of removal when the amount sinks so low as 0.20 per cent, or under. During the foregoing somewhat protracted process, large quantities of gases, principally carbon monoxide and hydrogen, are absorbed by the fluid metal, while a certain amount of oxide of iron becomes diffused through it. If these are in excess, the metal becomes what is technically termed "wild." This condition is brought about chiefly by too rapid additions of ore, and by adding more ore than is necessary to oxidize the carbon in the molten metal, resulting in the formation of a slag containing too much free oxygen. Metal of this kind emits large quantities of gases during solidification after casting, and causes the ingots to be honeycombed or spongy. Ingots of this description will neither hammer nor roll well. Even with the most careful working this difficulty must be expected to a certain extent, but can be partly overcome by the addition of ferro-manganese either before tapping or while the metal is running into the ladle. Ferro-manganese, as its name implies, is an alloy of iron and manganese rich in carbon, the analysis of the high quality, now generally used, being:

C.....	6.00
Si.....	0.52
S.....	trace
P.....	0.26
Mn.....	80.00
Fe (by difference).....	13.22
	100.00

The chemical action of the manganese, of which the alloy is mainly composed, consists in the reduction and removal of diffused oxides, metallic iron being formed and manganous oxide, which, being readily fusible, easily finds its way to the surface of the molten metal. To insure a good product, a sufficient excess of ferro-manganese should be added, the amount of manganese remaining in the finished steel being rarely under 0.40 per cent. In this connection the use of ferro-silicon (an alloy of iron, manganese and silicon) is also effective. By its employment a metal may be obtained which gives off considerably less gas on solidification, the ingots obtained being free from honeycomb, and require no sanding or wedging down. For certain purposes, such as in the manufacture of steel castings, this is an invaluable material for the steelmaker. Now, having roughly traced the manufacture of steel from the initial stage to the form of ingots, we take leave of the subject, the subsequent operations being purely mechanical and having no connection with the chemistry of the Siemens furnace.

THE DRAWING OF LOTS IN CONNECTION WITH THE REDEMPTION OF THE BONDS OF PARIS.

THE drawing of lots in connection with the redemption of the bonds of the city of Paris, payable with prizes or reimbursable at par, is done in public. The dates of it are announced by official notices. It takes place in the hall of the Palace of Industry.

All the loans, except those of 1855-1860, allow of four

fied the itinerary of their daily promenade, and in winter there are a few laborers out of work who know that there is a stove always roaring.

Shortly before the beginning of the operation laborers draw the wheel of fortune out of the closet in which it is inclosed. It slides upon rails to the center of the hall and one proceeds to put it in shape.

The cylinder, the convex surface of which is of copper, has two of its sides closed by double and transparent plates of glass, thus permitting the interior of



OPENING THE CASES THAT CONTAIN THE NUMBERS.

annual drawings. The operation of drawing begins at ten o'clock in the morning sharp.

The members of the commission (a counselor of prefecture, representing the prefect of the Seine, and four or five members of the Municipal Council) sit around a table covered with green baize placed upon a stage at the rear of the hall. The representatives of the newspapers have places reserved for them.

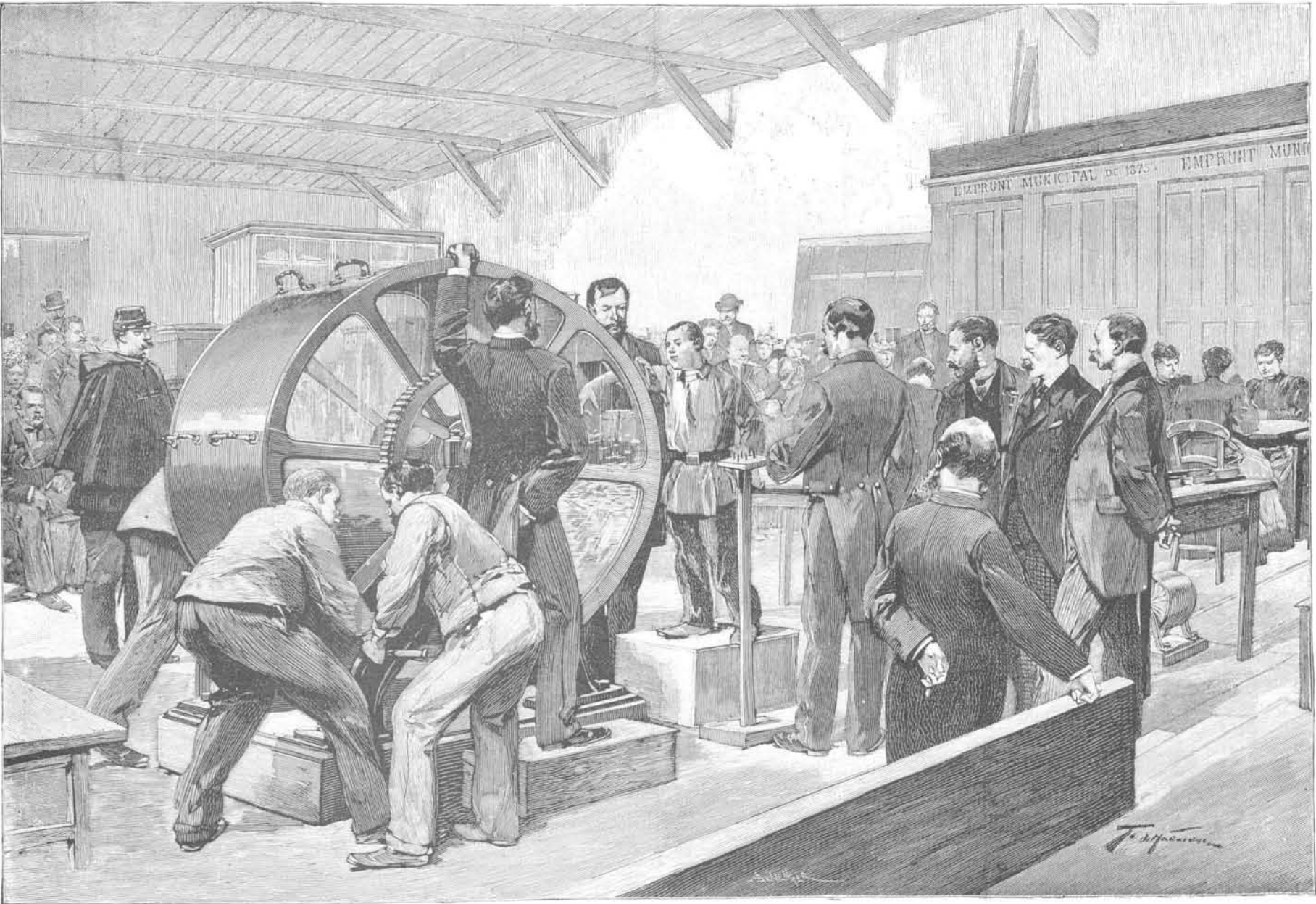
In the part of the hall preceding the stage are situated to the right and left the closets that contain the wheels of the municipal loans of 1855, 1860, 1865, 1869, 1871, 1875, 1876, 1886 and 1892. At a table are seated the male and female employees who are presently to take the lucky numbers from the cases.

In the second part of the hall, separated from the first by a wooden railing, stands the public. The physiognomies are almost always the same. There are types of avaricious women, with ears wide open to the calling of the numbers, and who leave with the appearance of people who have been robbed when their numbers have not been drawn; then there are small stockholders who, for one morning, have modi-

the wheel to be seen. The latter is provided with iron pyramids and cones in order to facilitate the mixing up of the numbers. In the cylinder there is an aperture which is closed by a small copper door provided with three locks. The key of one of these is placed in the hands of the president of the commission. The two other keys are kept by municipal councillors chosen by lot.

The cases in which the numbers are rolled consist of two small copper cylinders, one sliding in the other and held firmly in place so that the case cannot open easily. The numbers of the bonds are printed upon strong paper. Protected by the cases, they are capable of lasting a century at least without undergoing the least deterioration. It is well that this is so, since the last loans raised by the city are payable in forty-eight years.

At the hour fixed the president of the commission opens the session by announcing how many numbers are to be drawn from the wheel, and, in the order of their extraction, the prizes that they will win. Then, in the presence of his colleagues and the public, he



DRAWING THE PRIZES ON THE BONDS OF PARIS.