to the top of the supporting table, which is at all times parallel to the axis of rotation of the abrading wheel. It will readily be seen then that drawing the specimen across the periphery of the wheel will result in grinding upon it a surface that will be a perfect plane. The depth of the cut is of course governed by the micrometer screw and the sliding rod (E).

The abrading wheel is housed in a case (K) in which is packed a sponge, in contact with which it runs. This sponge is kept moistened by a fine stream of water which enters through a hose at the inlet (L) and serves the double purpose of moistening the abrading wheel and cleaning off the sludge. The outlet (M) serves as an overflow pipe for removing surplus water and sludge.

The microscope (N) is mounted on the supporting table in such a manner that it focuses on the spot on the periphery of the wheel where the grinding is taking place. The motor (O) furnishes the motive power for the abrading wheel.

Fig. 3 shows the specimen holder, enlarged about four times with respect to the other figures. It consists of a specimen clamp P, with checkered jaws which are closed upon the specimen by set screw Q. The upper part of the clamp consists of a ball R which is fitted into two circular depressions (S) ground in the clamp bars T and U. The latter are fastened at either end to the base plate V, T being fixed in its position, while U is allowed to move slightly in a plane parallel to the base plate by means of the slot W. X is the clamp screw by means of which the ball R is clamped in the desired position.

In operation the process is simple. The specimen is placed in the jaws of the clamp of the specimen carrier, orientated and made fast. The specimen carrier is then placed with its plane lower surface upon the plane upper surface of the supporting table and the clamp, with the specimen in it, projecting down through the opening in the table. The table is then lowered by means of the sliding rod until the specimen comes in contact with the abrading wheel. It is then planed off and the lowering process continued by means of the micrometer screw until the desired plane is reached. If, however, after making a cut or two it is found that the preliminary orientation was not correct, the clamp is shifted in its universal joint until the desired position is reached and then made fast again, with respect to the specimen carrier. The specimen carrier is again placed on the supporting table and the process of grinding continued.

When the desired plane has been reached, the specimen is taken out of the clamp and cemented to a slide with Canada balsam, that has been cooked until it will shatter when crushed under a testing tool. The glass slide then assumes the rôle of specimen carrier, which it replaces at this stage, and the specimen is ground down from the other side in the same manner as before, except that now the process may be observed through the microscope as the grinding progresses. Thus one is enabled to observe the changing appearance of the slide as it becomes thinner, and to stop the process when the desired amount of detail is observed.

As will be apparent, one of the greatest advantages of this machine is the fact that it affords perfect control at all times. Once the specimen is orientated and clamped in the specimen carrier, this orientation is assured throughout the process, regardless of the number of times the specimen carrier is removed from the table for observation or other purposes. Through the micrometer screw the depth of each cut may be minutely regulated, thus enabling the operator to stop at any desired plane. As noted above, the microscope reveals the changing character of the specimen as it is ground thinner and thus enables the operator to stop at the most advantageous thickness.

Another advantage which is worthy of note is the fact that the surfaces of the specimen slice are parallel planes. This fact removes the danger of losing part of the specimen, when taking it to thinness, by grinding away one edge. And last, but by no means least, is the speed factor. While the time required to make a section of a fossil will vary with the character of the material to be sectioned and the experience of the operator, it will in most cases be found that only about one sixth as much time is required with this machine as with the older methods.

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SPECIAL ARTICLES

SERIES IN THE ARC SPECTRUM OF CHLORINE[1]

AT various times during the past five or six years wave-length measurements of the spectrum of chlorine have been made at the Bureau of Standards. This work has corroborated to a large extent previous investigations by others describing limited portions of the spectrum, and has extended our knowledge of the spectrum into the hitherto unexplored regions in the red and infra-red. These new wave-lengths, characteristic of the arc and spark spectra as emitted

[1] Publication approved by the Director of the Bureau of Standards, of the U. S. Department of Commerce.

by Cl-filled Geissler tubes, extend from 2300A in the ultra-violet to 9900A in the infra-red.

With the aid of these new lines and those in the extreme ultra-violet, published by Turner,[2] we have succeeded in working out the structure of the arc spectrum of chlorine, Cl I. In its unexcited state the outer electron configuration of the chlorine atom is s^2p^5 from which, according to Hund's theory,[3] we may expect the lowest term of the spectrum to be ^2P. This term and others arising from the various electron configurations assumed by the excited atom are based on the term ^3P of Cl II, which was established by Bowen.[4] In the following table are listed the theoretical terms to be expected, those already found in this investigation being printed in heavy type. Terms based on ^1D and ^1S of Cl II will produce only faint lines and are here omitted.

Electron Configuration	Doublet System Terms	Quartet System Terms
s^2p^5	**P**	
$s^2p^4 \cdot 3d$	F D P	F D P
$s^2p^4 \cdot 4s$	**P**	**P**
$s^2p^4 \cdot 4p$	**D P S**	**D P** S
$s^2p^4 \cdot 4d$	F D P	F D P
$s^2p^4 \cdot 5s$	P	P
$s^2p^4 \cdot 5p$	**D P S**	**D P** S

Turner's lines, already interpreted by Bowen[5] and by Laporte,[6] represent the combinations of the odd lowest ^2P term with the higher even terms ^2P and ^4P coming from the configuration $s^2p^4 \cdot 4s$. The new lines in the red and infra-red represent the combinations of ^2P and ^4P ($s^2p^4 \cdot 4s$) with the doublet and quartet, S, P, and D terms arising from $s^2p^4 \cdot 4p$. A still higher set of doublet and quartet, S, P, and D terms arising from $s^2p^4 \cdot 5p$ combines with the even terms ^2P and ^4P to give the arc lines in the blue and violet described by Asagoe[7] and beautifully illustrated in the map given by Eder and Valenta.[8]

It is thus seen that in structure Cl I closely parallels A II, recently worked out by De Bruin.[9] The ^2S and ^2P terms which arise when the activated electron is raised to the $4p$, $5p$, . . . orbits, form Rydberg series from which the value of the lowest term may be derived. This value turns out to be 106000 which agrees with the value 105000 found by interpolation from those for S I and A I. The ionization potential of the neutral chlorine atom is therefore 13.1 volts.

The details of the investigation will appear in an early number of the *Bureau of Standards Journal of Research*.

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2 Turner, *Physical Review*, 27: 402, 1926.

3 Hund, "Linienspektren und Periodisches System der Elemente," Berlin, 1927.

4 Bowen, *Physical Review*, 31: 34, 1928.

5 Bowen, *Physical Review*, 31: 498, 1928.

6 Laporte, *Nature*, 121: 1021, 1928.

7 Asagoe, *Mem. College of Science*, Kyoto, A 10: 15, 1926.

8 Eder and Valenta, "Beiträge zur Photochemie und Spectralanalyse," Vienna, 1904.

9 De Bruin, *Kon. Akad. Wet. Amsterdam*, 37: 553, 1928. *Zeitschrift für Physik*, 48: 62, 1928; and 50: 1928.

THE RELATION OF CERTAIN BACTERIA TO THE DEVELOPMENT OF ROOTS[1]

AN excessive localized development of small fibrous or fleshy roots has long been observed to occur on varying percentages of young apple trees in the nursery. Considerable doubt has attached both to the cause of this "hairy-root" condition and its effect upon the tree. The first important contribution to the knowledge of the etiology of this trouble was made by Smith and his coworkers[2] in their extensive researches on crowngall. They isolated from "hairy-root" malformations on young apple plants bacteria which they state "culturally and morphologically differ, if at all, only slightly from the crowngall organism." They report that five of eight young apple trees inoculated through punctures with these bacteria developed hairy-root symptoms, one developed galls and the other two remained free from malformations. Of four controls, none developed hairyroot, though one developed several galls. They do not report reisolation of the organism from hairyroot malformations on the inoculated plants or precautions to preclude the possibility that organisms from the soil may have played a part in inducing these hairyroot developments. However, they isolated from the inoculated tree which developed only galls an organism which, when plated, "looked typical for what was inserted." They state that this organism, when inoculated into healthy sugar beet, "produced both galls and hairy roots, indicating

1 Published with the approval of the director of the Wisconsin Agricultural Experiment Station. These studies were begun as a part of the Wisconsin program in the crowngall project supported cooperatively by the Crop Protection Institute, the Iowa State College of Agriculture and Mechanic Arts and the University of Wisconsin, and have been continued in cooperation with the United States Department of Agriculture.

2 E. F. Smith, Nellie A. Brown and C. O. Townsend, "Crowngall of Plants: its Cause and Remedy," U. S. Dept. Agr., Bur. Plant Indus. Bul. 213: 200, 1911.