THE HELIX CHEMICA

B. K. EMERSON

Amherst, Massachusetts

In 1911 I devised a helical arrangement of the elements (1) which, being a three-dimensional projection as compared with the two-dimensional table of Mendeleeff, still seems the best for presenting the multiform relations of the periodic system and for predicting new relationships. The helix has an exceptional value as a scheme of representation since it can be drawn so simply, can be viewed from the side as well as from the end, and because it expresses a fundamental harmony in a spiral whose coils increase in size and number according to the simplest geometrical ratio of the powers of two while the interspaces (representing interweights) increase by the simplest arithmetical series, 1, 2, 3, 4, etc.

The purpose of this paper is to show that the addition of two small coils at the origin of the helix as originally published perfects it and that the full development of the series of the powers of two demands this addition. It requires one additional element before hydrogen but this addition completes the symmetry of the elemental series. The same symmetry suggests the existence of two new elements between hydrogen and helium as well as the two preceding hydrogen.

THE ORIGINAL HELIX

In constructing the helix in 1911, as shown in figure 1, I started with the recognition of two symmetrical groups, of eight elements each, in two circles,—the octaves,—followed by four similar groups of sixteen elements each (counting the triads as one) in four circles,—the double octaves,—and the first quadrant of a larger circle with 32 elements,—the quadruple octave. This symmetry demanded at the other end, going backward from the

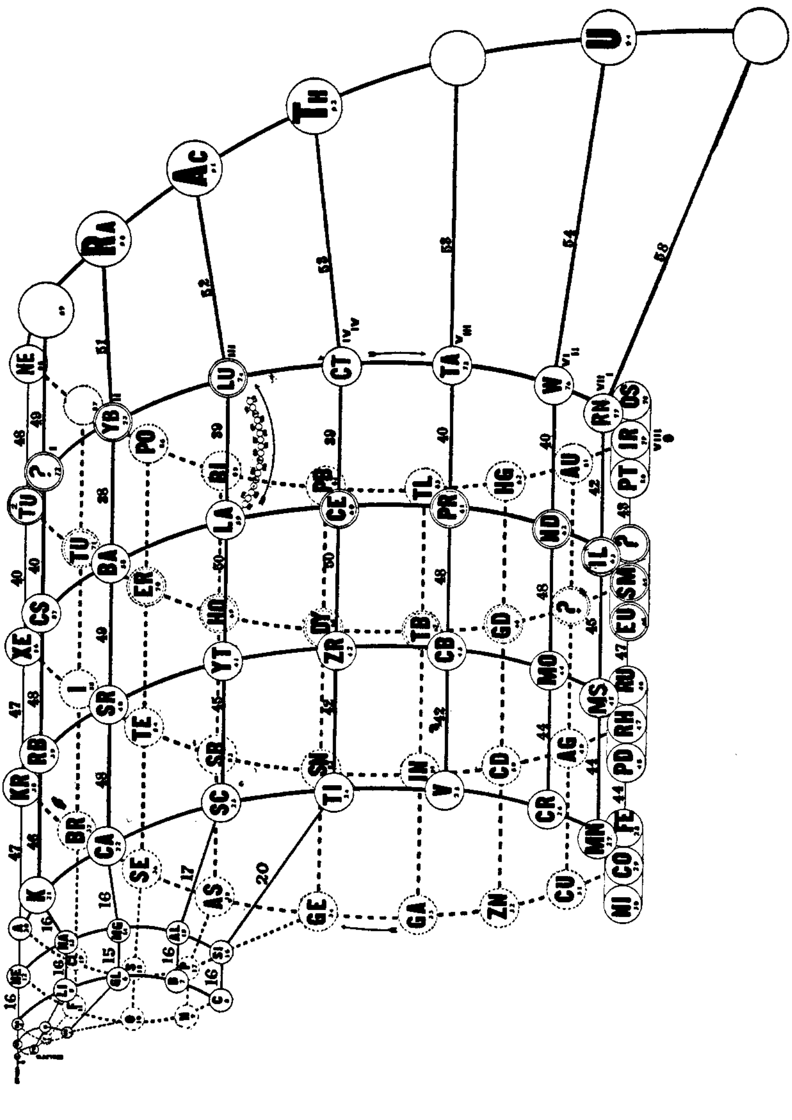

FIG. 1. A SIDE VIEW OF THE HELIX AS ORIGINALLY PUBLISHED

The Rydberg ordinal numbers (greater by two than the Moseley atomic numbers) and the transverse interweights are given. E at the beginning should be AE.

first octave, a single group of four elements, hydrogen to helium, in a single circle and a first group of two elements, ether and coronium, in a half-circle. In the original helix it was recognized that the numbers of the rings of the helix, which symbolized the succession of the elements as well as the number of elements in each type of ring, increased as the powers of two.

It will be noted that the elements are placed symmetrically in the order of their increasing atomic weights upon the successive coils of the helix. The distance between successive elements on the helix, the interspaces, are made proportional to the successive increments in atomic weight, the interweights. Thus in the half-octave with four elements (H = 1 to He = 4) the interweight is one and the interspaces are given this unit length. In the octaves the elements increase by two units of atomic weight, which are so represented as spaces. They average three each in the double octaves and four in the quadruple octave. As shown in figure 3, these interweights sometimes vary from the average by a full unit but in the figures the average is taken, which brings each group of common valence into a straight line. The use of the true values would make each line zigzag sharply yet remain separate from its neighbors.

THE EMENDED HELIX

In the original helix the ether and the electron were blended in a single symbol, E, which was joined with the element coronium in the first half-circle. This seemed infelicitous even then and Nicholson's investigations, demanding an additional element before hydrogen, caused a reconsideration of the question. It was then seen that the algebraic decrease in the powers of 2 and the geometric decrease in the coils of the helix had not been fully appreciated. The complete series of the elements can, on this plan of symmetry, be symbolized by the complete series of the powers of 2, i.e. $2^{-\infty} = 0; 2^{-1} = \frac{1}{2}; 2^0 = 1; 2^1 = 2; 2^2 = 4; 2^3 = 8; 2^4 = 16; 2^5 = 32$. The full geometrical implications of this series are shown in the helix of figures 2, 3, and 4. Thus if 2^2 represents a half-octave with four elements and 2^1 represents a fourth-octave with two elements, the question lies in the signifi-

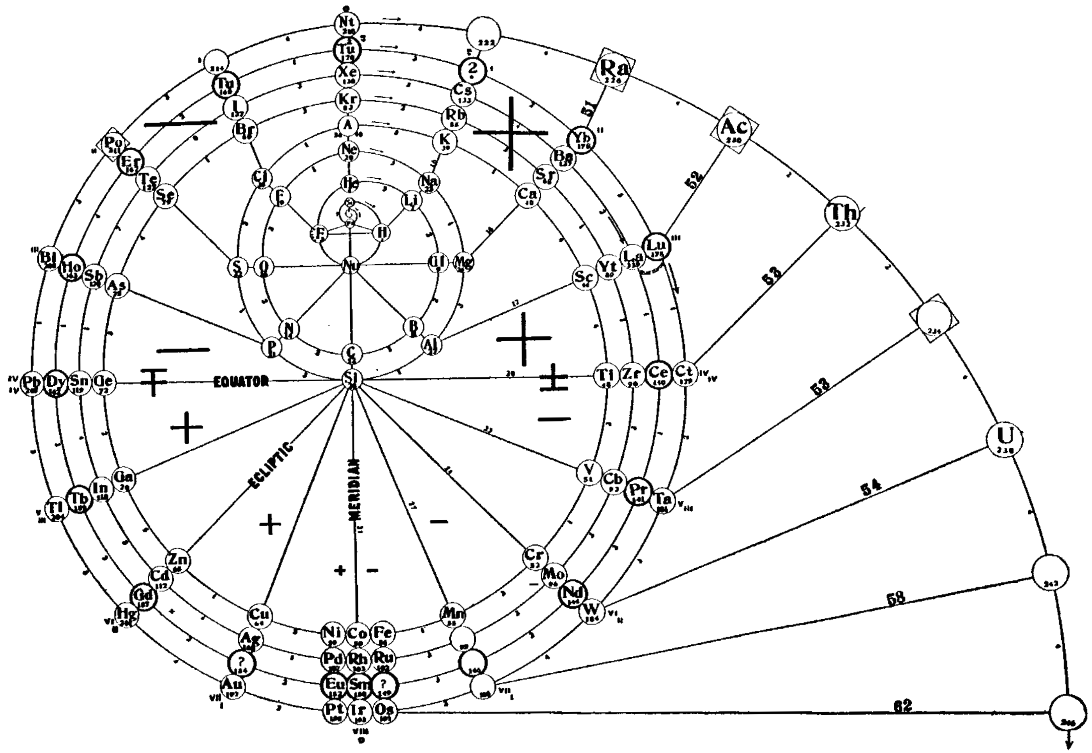

FIG. 2. THE HELIX FROM THE END

The longitudinal interweights are given and also the transverse interweights at the flares. The rare earths are each enclosed in a double circle and the short-circuiting from La to Lu is indicated by a long curved arrow. On the eighth line down, the symbol directly under He should be Cn instead of Si as printed.

cance of 2^0, 2^{-1}, 2^{-2}, etc. Geometrically the case is one of decreasing radii, since a coil of the helix with four symmetrical radii makes place for four elements while the next smaller coil, with two radii, makes place for two.

The origin, O. The first step in the construction of the helix as a working model of the evolution of the elements is the fixation

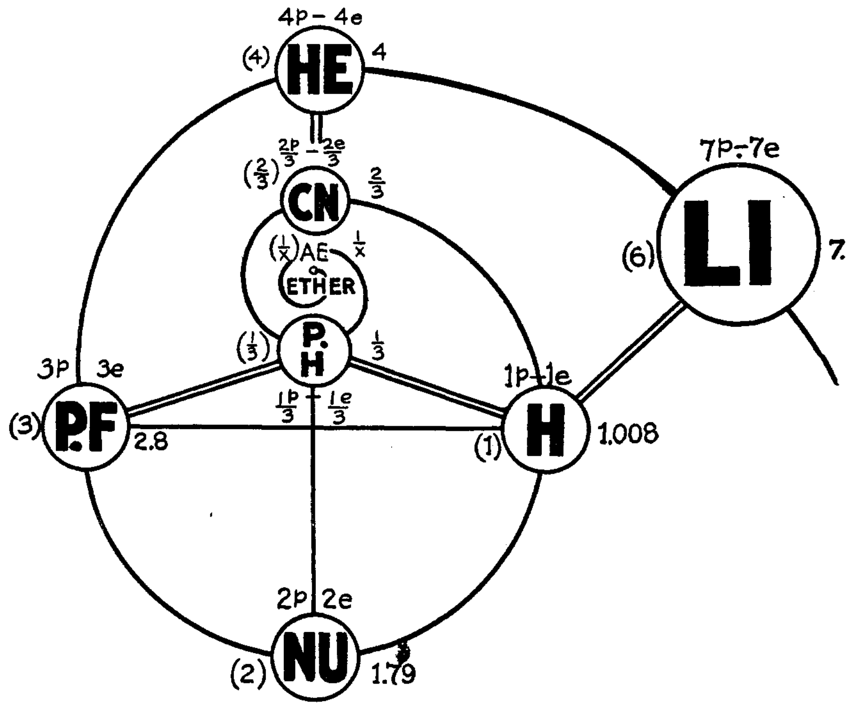

Fig. 3. Enlargement of the First Three Coils

Data given are the atomic composition, the ideal atomic weights in brackets and the observed or calculated atomic weights.

of the point of origin, O, in the ether or the electrical source of the vortex motion that is to form the simplest unknown elemental matter. This point, as being without dimensions, may be expressed by zero and, as it is a sample of every point in the infinite ether, its summation may equal infinity. The word ether is therefore placed at the beginning of the helix. Algebraically this is expressed by $2^{-\infty} = 0$.

The first circle; the ante-element. A radius vector occupies this point, O, and is at first without length, *et crescit eundo.* At the end of its first full rotation it has the infinitesimal length, O – AE (fig. 4), suggested by the mass of the primal substance which is formed by the vortex motion in the ether and typified by this rotation. This ante-element, AE, may thus represent the passage of the ether into the simplest transitional form of matter or the unknown action by which electricity passes into its first stable form. This may represent the electron, or, possibly, Ehrenhaft's sub-electron. The whole length of this circle represents the first interweight and is almost infinitesimal in all its parts.

The second circle; proto-hydrogen and coronium. Continuing the helix into the second circle, the two radii, O – PH and O – Cn, placed at the middle and the end of this circle, mark the positions of two undiscovered elements with fractional weights, named proto-hydrogen and coronium, which are thus at the ends of a single vertical diameter and represent algebraically the next distinctive term in the series $2^1 = 2$. These elements may be assigned one and two protons, respectively, as was done by Nicholson (2), and as is suggested by the equations for the elements derived from Thompson's formula for matter. All chemical work, however, is based on H = 1, so that PH = $\frac{1}{3}$p – $\frac{1}{3}$e, and Cn = $\frac{2}{3}$p – $\frac{2}{3}$e. These fractional values, while maintaining the proper ratio, may fitly typify these possible inert, transitional, coronal and nebular elements. "In fact," says Nicholson, "the nebulae must be composed of a set of chemical forms which are the simplest forms in which matter can exist. They are not isotopes because they have different spectra. The spectrum of a nebula may be described as the spectrum of chaos. Whatever may occur with terrestrial atoms, the electrons in a nebula are not held very firmly in the atoms and a continual interchange of electrons must be taking place, with a necessary bombardment of atoms by free electrons, to which the luminosity is probably due. The first products of an evolution of some form from these systems leads ultimately to the Wolf-Rayet stars in which series analogous to the terrestrial series may be found." The Wolf-Rayet stars are supposed to be developing into normal stars by the growth of a simple nucleus at their centers. W. H. Wright (3) suggests that the nuclei of the planetary nebulae are closely related to the Wolf-Rayet stars and in many cases are such stars. He supposes that the order of condensation or settling into the nucleus from the nebulae is helium, nebulium and hydrogen.

On the helix proto-hydrogen is the first of the inert gases, standing above the center of the figure at the beginning of the series and symmetrically between hydrogen with a valence of +1 and proto-fluorine with a valence of −1. Its valence is thus 0. Coronium, above proto-hydrogen, stands also in the series of the inert gases and so has a valence of 0. This second circle of the helix, with only one diameter, is not yet completely symmetrical and thus characterizes the two fractional elements. This is the first introduction of "matter."

The third circle. The next circle, the half-octave, is cut geometrically by four radii, typified algebraically by $2^2 = 4$. There is thus place for four elements and the previous interspace of $\frac{1}{3}$ becomes 1. These elements have respectively 1, 2, 3 and 4 electrons or protons and are formed by the successive addition of a single hydrogen atom. Their ordinal numbers (N) are the same as the number of protons contained and their atomic weights are approximately 1, 2, 3, and 4. This circle, with two diameters at right angles to each other, is the first completely symmetrical circle and so has the first stable and integral elements: hydrogen, the building stone of this first circle, and helium, the building stone of the last circle. These are the first terrestrial elements. They are accepted by Rydberg (see below) and, as possibilities, by Aston.

The fourth group of two circles. With the development of these two stable forms complexity becomes possible. In the next group of two circles ($2^1 = 2$) two hydrogen atoms tend to be added to each new form and so the interspace becomes two. Four diameters are drawn so that the number of interspaces becomes eight (algebraically $2^3 = 8$). Hence so stable a combination, the octave, has been reached that two circles are formed, the most typical, symmetrical and equally differentiated of the whole series. At the bottom of these two circles, at the very center and umbilicus of the helix stand silicon and carbon, the ideal elements. One is the basis of the inorganic world and the other of the multitudinous compounds of the organic world. Both are embryonic triads.

The fifth group of four circles. Next, with the serial addition of 3H, a double-octave circle is formed having 8 diameters and thus place for 16 elements ($2^4 = 16$) which at first simulates the preceding circle but diverges downward from it into a larger circle. Passing titanium it goes down with increasing atomic weight, valence and density to the iron triad and rises with a symmetrical decrease of all these properties except atomic weight to germanium, which balances titanium opposite silicon. Thence it corresponds with the left half of the octave, reaching zero valence in krypton. It thus forms a circle of double size which occurs four times ($2^2 = 4$) with decreasing fidelity to type because of increasing bulk.

The triads. The equation, $2^4 = 16$, demands a circle of sixteen places. The three complete double-octaves which occupy these circles each contain 18 elements. The lowest position on each circle is therefore occupied by three similar elements, each having a valence of 8,—a triad. In completing the imperfect third double-octave, where three elements had to be supplied the most probable additions are indicated by question marks in the figures. One is the first element of a similar triad and another is the first element following the triad.

The sixth circle. Then comes the successive addition of 4H (or He), forming again a circle of double the previous size, a quadruple-octave. This becomes too complex for complete development or stability, as is indicated by the sudden appearance of radioactivity. Here the interspace becomes 4, the number of diameters 16, the number of elements 32, and the number of rings, if developed, would be 8. These numbers are extrapolations by the use of the series of the powers of 2 which have been found to apply in the earlier parts of the helix among existing elements.

The flares of the helix. If we subtract the atomic weights of the inner octave from the corresponding members of the outer octave, as C = 12 from Si = 28, or O = 16 from S = 32, we get a constant difference of 16 because we are subtracting values which increase by two from values which increase by two. But if, in a similar manner, we subtract values in the outer octave from corresponding values in the first double-octave there is a gradual increase in the difference, from 16 to 32, since we are subtracting numbers which increase by two from numbers which increase by three. Following this flare the differences between the weights of corresponding members of the double-octaves again become constant at 48. But a new flare appears beyond the fourth double-octave and the differences again increase. These values may form a criterion for the judgment of those arrangements of the periodic table which, like that of Rydberg (4) adopted by Harkins (5), postulate two octaves, two double-octaves and two octo-octaves with 64 elements each. This demands a flare after passing xenon, but Kr − Xe = 47, Sr − Ba = 49, Cb − Pr = 48, Mo − Nd = 48, and so on, which shows that the third double-octave is strictly parallel to the two preceding ones. The arrangement of Hackh (6), which unites the third and fourth double-octaves in a single coil, is subject to the same criticism.

THE ATOMIC OR ORDINAL NUMBER; THE MOSELEY NUMBER

The number two when it stands for the nuclear charge of helium, its number of nuclear or of exterior electrons, or for half its atomic weight, represents fundamental characteristics of its atomic structure. When it is also used as its ordinal number or "atomic number" it expresses only the coincidence that helium happens to be the second *terrestrial* element recognized in the long established Mendeleeff table of the elements, which ignores the celestial elements after and perhaps before hydrogen. Throughout the two octaves there is an average increase of 2 in weight for each additional element so that the atomic weight is close to twice the atomic number. The heavier elements, however, have weights which are greater than twice their atomic number. The divergence begins at argon, i.e. where the double-octaves attach to the octaves. Thereafter the increment in weight is three and the division of the atomic weight by two no longer gives the atomic number. The weights are, however, so large that the percentage error is small and the error is overlooked in the common statement of the relationship.

The Moseley series of atomic numbers does not exclude the possibility of further elements below helium. Nicholson (7) says, "It is not necessary to admit that the atomic number of an element corresponds *exactly* to its position in the table as we know it. . . . . Other elements may exist between hydrogen and lithium besides helium, ... and . . . . the supposition that the atomic numbers of lithium, glucinum, and boron are (necessarily) 3, 4 and 5, respectively, cannot be admitted on theoretical considerations." Uhler (8), on the basis of the determinations of the x-ray spectra of the elements, declares that "the law must not be taken so literally as to mean that the x-ray data used by Moseley alone necessitate associating the integers 1, 2,...13,...74,...92, with H, He, Al, W, and U, respectively." Indeed the atomic numbers need not even be integral.

Langmuir's concept of an octet of eight electrons has become established. A quartet is also possible and is suggested by symmetry for the lighter elements. Lande gives an elaborate mathematical justification for the arrangement of the centers of rotation of the electrons at the corners of a tetrahedron as well as at the corners of a cube. This model has been adopted, at least in part, by Langmuir (9).

THE RYDBERG ARRANGEMENT OF THE ELEMENTS COMPARED WITH THE HELIX

The Rydberg diagram (fig. 4) (11) offers a significant comparison with the helix. For this purpose the projection of the helix is represented in figure 5. The differences between the two are tabulated in table 1. The two differ chiefly in that Rydberg's table has two rings in each group while the number of rings in the successive groups of the helix increases in number as the powers of 2. Table 1 shows that the two differ immediately after the origin to permit the insertion of the two series representing 2^0 and

2^1 in the helix. Again, from the point of view of the helix the elements from hydrogen to helium form a single circle and not two loops, though this may remain somewhat uncertain until the valence of the intervening elements is known. From this point on the two tables are identical to the beginning of the fourth group. At that point the divergence of the two is radical, for the helix demands two additional double-octaves, or four in all, and utilizes the elements of the first loop of Rydberg's Group IV for this purpose.

In figure 4 the fourth group, beginning at xenon, should extend to the right to twice the width of the table but it is bent back at samarium in order to put homologous elements beneath each other, particularly the triads, Os, Ir, Pt, and Fe, Co, Ni. This forces the Rydberg diagram into a resemblance to the helix and compels the apparent insertion of an incomplete third double-octave of the rare earths, Cs to Tu, which is frankly recognized in the helix as an actual double-octave. This has been proposed by Bohr (12) in his discussion and revision of Rydberg's table.

In the helix provision for eighteen elements in each double-octave is accomplished by the triads in the octo-valent position. To provide the 18 elements in the rare earth series four unknown elements are inserted including three adjoining samarium and the element Tu 2, which is already widely accepted (13). Vogel (14) cites three separate culminations of chemical and physical properties at samarium and europium, which correspond with a triad culmination in the helix. He presents several considerations which favor a third double-octave for the rare earth group, as in the helix. Kirchof (15) has shown that the colored ions, which are found two or three places on either side of the triads in the normal double-octaves, are even more widely spread in the corresponding positions in the rare earths.

It would seem preferable to consider the thulium-samarium group as an abnormal double-octave among the others than to make it the beginning and type of a still larger group, as Rydberg does, because this latter would demand a marked similarity between the rare earths and the radio-elements which stand at the beginning of the second of these longest groups. But the dissimi-

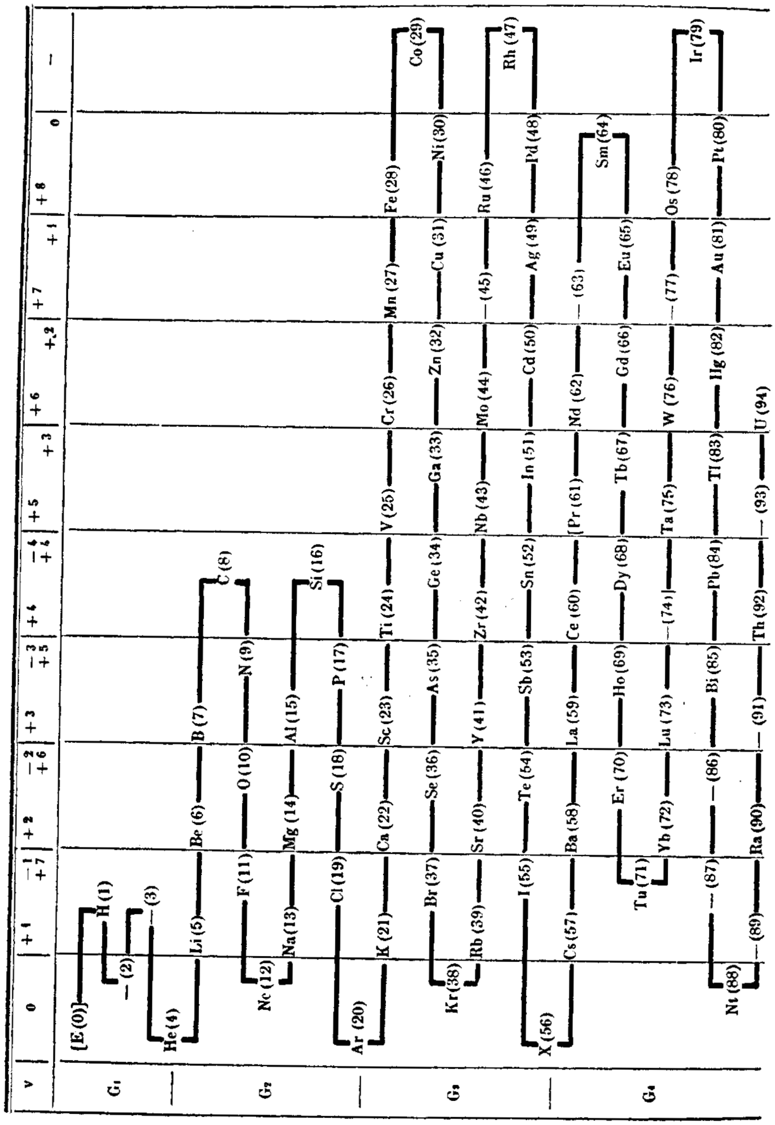

FIG. 4. THE RYDBERG DIAGRAM OF THE PERIODIC SYSTEM

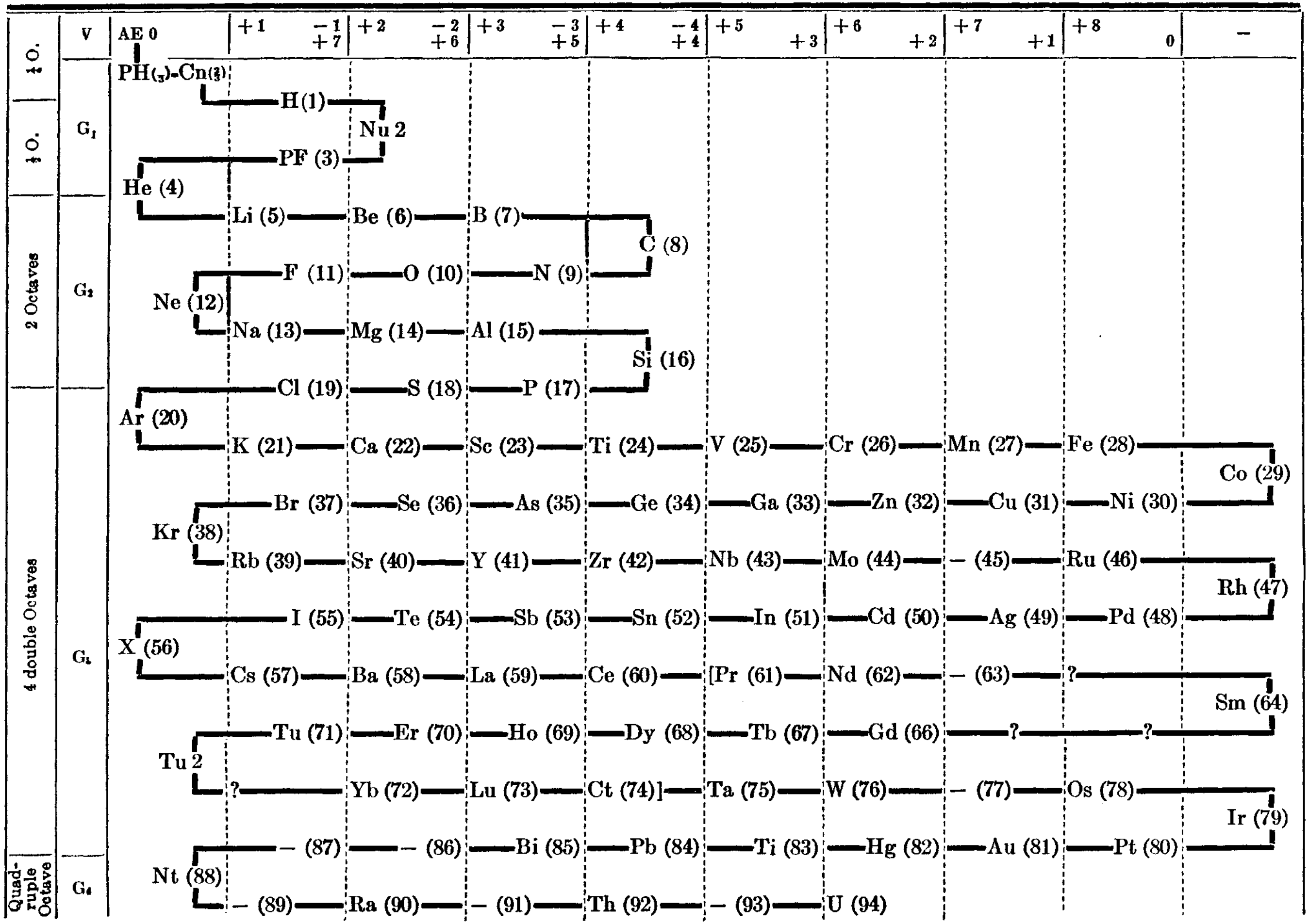

Fig. 5. Modification of the Rydberg Diagram to Conform with the Helix

The two loops of Group I are united, H to He, and the third double octave X to Tu2, is completed larity between them is striking and in the helix the most marked of all the flares separates the two groups and argues against any direct similarity.

The short-circuiting of the elements between lanthanum and tantalum as has often been proposed and is expressed in the

TABLE 1

Comparison of the Helix with the Rydberg Table

THE HELIX			THE RYDBERG TABLE		
Subdivision	Scheme	Number of elements	Subdivision	Scheme	Number of elements
Origin	$2^{-\infty}$	0	Group O 1st loop 2nd loop	 2×0^2 2×0^2	0 0 } $0 = 0^2$
1 Circle	2^0	1 (ante-element)			
1 Circle	2^1	2 (fractional elements)			
1 Circle	2^2	4 (½ octave)	Group I 1st loop 2nd loop	 2×1^2 2×1^2	2 2 } $4 = 2^2$
2 Circles	2^3 2^3	8 8 } (2 octaves)	Group II 1st loop 2nd loop	 2×2^2 2×2^2	8 8 } $16 = 4^2$
4 Circles	2^4 2^4 2^4 2^4	16 16 16 16 } (+2 in triads) (4 double-octaves, total, 72)	Group III 1st loop 2nd loop	 2×3^2 2×3^2	18 18 } $36 = 6^2$
8 Circles	2^5	32 (quadruple-octaves)	Group IV 1st loop 2nd loop	 2×4^2 2×4^2	32 32 } $64 = 8^2$
(Only 6 radioactive elements formed in first circle or loop)					

diagrams of Soddy and of Harkins, is a practical convenience but it is a surrender rather than a solution. It is expressed in the figures 1 and 2 by an arrow joining La with the main curve below Ct and by indicating the omitted ring by heavier circles around the symbols of the elements omitted. Rydberg rejects entirely this short-circuiting plan and has made elaborate calculations of the positions of the rare earth elements. His arrangement of the individual elements has been closely followed in the helix.

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