Zinc Triplets.			Calcium Triplets.		
A.	B.	C.	A.	B.	C.
2992	37	19	2245	10	5
3257	38	20	2517	11	5
3371	40	18	2744	10	6
3686	40	19	2868	10	6
3833	40	18	2977	10	5
3975	38	19	3044	11	6
4057	41	17	3101	11	5
			3174	10	5
			3208	10	--

Magnesium Triplets.					
Cornu.			Hartley and Adeney.		
A.	B.	C.	A.	B.	C.
1929·3[1]	4·2	1·9	2605·6	3·9	2·0
2605·8	4·1	1·7	2997·4	4·0	2·4
2999·2	3·8	2·7	3229·8	4·5	2·1
3230·4	3·9	1·9			
3399·0[2]	4·1	1·2			

Relation between Spectrum of a Body and Spectra of its Compounds.

The spectrum of a body is due to periodic motion within the molecules. If we are justified in believing that the molecule of mercury vapour contains a single atom, it follows that atoms are capable of vibration under the action of internal forces, for mercury vapour has a definite spectrum. We may consider, then, the spectrum to be determined in the first place by forces within the atom, but to be affected by the forces which hold together the different atoms within the molecule. The closer the bond of union the greater the dependence of the vibrations on the forces acting between the different atoms. Experimental evidence seems to favour these views, for we observe that whenever elements are loosely bound together we can recognize the influence of each constituent, while in the compounds which are sufficiently stable to resist the temperature of incandescence the spectrum of the compound is perfectly distinct from the spectra of the elements. The oxides and haloid salts of the alkaline earths, for instance, have spectra in which we cannot trace the vibrations of the component atoms; but the spectra of the different salts of the same metal show a great resemblance, the bands being similar and similarly placed. The spectrum seems displaced towards the red as the atomic weight of the haloid increases. No satisfactory numerical relationship has, however, been traced between the bands. The number of compounds which will endure incandescence without decomposition is very small, and this renders an exhaustive investigation of the relationship between their spectra very difficult.

The compounds whose absorption spectra have been investigated have often been of a more unstable nature, and, moreover, dissociation seems going on in liquid solutions to a large extent; the influence of the component radicals in the molecule is more marked in consequence. Dr Gladstone,[3] at an early period in the history of spectrum analysis, examined the absorption spectra of the solution of salts, each constituent of which was coloured. He concluded that generally, but not invariably, the following law held good: "When an acid and a base combine each of which has a different influence on the rays of light a solution of the resulting salt will transmit only those rays which are not absorbed by either, or, in other words, which are transmitted by both." He mentions as an important exception the case of ferric ferro-cyanide, which, when dissolved in oxalic acid, transmits blue rays in great abundance, though the same rays are absorbed both by ferro-cyanides and by ferric salts. Soret has confirmed, for the ultra-violet rays, Dr Gladstone's conclusions with regard to the identity of the absorption spectra of different chromates. The chromates of sodium, potassium, and ammonia, as well as the bichromates of potassium and ammonia, were found to give the same absorption spectrum. Nor is the effect of these chromates confined to the blocking out simply of one end of the spectrum, as in the visible part, but two distinct absorption bands are seen, which seem unchanged in position if one of the above-mentioned chromates is replaced by another. Chromic acid itself showed the bands, but less distinctly, and Soret does not consider the purity of the acid sufficiently proved to allow him to draw any certain conclusion from this observation. Erhard's work on the absorption spectra of the salts in which chromium plays the part of base has already been mentioned. Nitric acid and the nitrates of transparent bases, such as potassium, sodium, and ammonia, show spectra, according to Soret, which are not only qualitatively but also quantitatively identical; that is to say, a given quantity of nitric acid in solution gives a characteristic absorption band of exactly the same width and darkness, whether by itself alone or combined with a transparent base. It also shows a continuous absorption at the most refrangible side, beginning with each of the salts mentioned at exactly the same point. The ethereal nitrates, however, give different results. In 1872 Hartley and Huntington examined by photographic methods the absorption spectra of a great number of organic compounds. The normal alcohols were found to be transparent to the ultra-violet rays, the normal fatty acids less so. In both cases an increased number of carbon atoms increases the absorption at the most refrangible end. The fact that benzene and its derivatives are remarkable for their powerful absorption of the most refrangible rays, and for some characteristic absorption bands appearing on dilution, led Hartley to a more extended examination of some of the more complicated organic substances. He determined that definite absorption bands are only produced by substances in which three pairs of carbon atoms are doubly linked together, as in the benzene ring. More recently[4] he has subjected the ultra-violet absorption of the alkaloids to a careful investigation, and has arrived at the conclusion that the spectra are sufficiently characteristic to "offer a ready and valuable means of ascertaining the purity of the alkaloids and particularly of establishing their identity." "In comparing the spectra of substances of similar constitution it is observed that in such as are derived from bases by the substitution of an alkyl radical for hydrogen, or of an acid radical for hydroxyl, the curve is not altered in character, but may vary in length when equal weights are examined. This is explained by the absorption bands being caused by the compactness of structure of the nucleus of the molecule, and that equal weights are not molecular weights, so that by substituting for the hydrogen of the nucleus radicals which exert no selective absorption the result is a reduction in the absorptive power of a given weight of the substance. . . . Bases which contain oxydized radicals, as hydroxyl, methoxyl, and carboxyl, increase in absorptive power in proportion to the amount of oxygen they contain."

It would seem, however, by comparing the above results with those obtained by Captain Abney and Colonel Festing[5] that the absorption of a great number of organic substances is more characteristic in the infra-red than in the ultra-violet. Some of the conclusions arrived at by these experimentalists are of great importance, as the following quotations will show:—"Regarding the general absorption we have nothing very noteworthy to remark, beyond the fact that, as a rule, in the hydrocarbons of the same series those of heavier molecular constitution seem to have less than those of lighter." This effect agrees with the observations made by Hartley and Huntington in the ultra-violet, in so far as a general shifting of the absorption towards the red seems to take place as the number of carbon atoms is increased. Such a shifting would increase the general absorption in the ultra-violet as observed by Hartley and Huntington, and decrease it in the infra-red as observed by Abney and Festing. Turning their attention next to the sharply defined lines, the last named, by a series of systematic experiments, concluded that these must be due to the hydrogen atoms in the molecule. "A crucial test was to observe spectra containing hydrogen and chlorine, hydrogen and oxygen, and hydrogen and nitrogen. We therefore tried hydrochloric acid and obtained a spectrum containing some few lines. Water gave lines, together with bands, two lines being coincident with those in the spectrum of hydrochloric acid. In ammonia, nitric acid, and sulphuric acid we also obtained sharply marked lines, coincidences in the different spectra being observed, and nearly every line mapped found its analogue in the chloroform spectrum, and usually in that of ethyl iodide. Benzene, again, gave a spectrum consisting principally of lines, and these were coincident with some lines also to be found in chloroform. It seems, then, that the hydrogen, which is common to all these different compounds, must be the cause of the linear spectrum. In what manner the hydrogen annihilates the waves of radiation at these particular points is a question which is, at present at all events, an open one, but, that the linear absorptions, common to the hydrocarbons and to those bodies in which hydrogen is in combination with other elements, such as oxygen and nitrogen, are due to hydrogen, there can be no manner of doubt. The next point that required solution was the effect of the presence of oxygen on the body under examination. . . . It appears that in every case where oxygen is present, otherwise than as a part of the radical, it is attached to some hydrogen atom in such a way that it obliterates the radiation between two of the lines which are due to that hydrogen. . . . If more than one hydroxyl group be present, we doubt if any direct effect is produced beyond that produced by one hydroxyl group, except a possible greater general absorption; a good example of this will be found in cinnamic alcohol and phenylpropyl alcohol, which give the same spectra as far as the special absorptions are concerned. . . . Hitherto we have only taken into account oxygen which is not contained in the radical; when it is so contained it appears to act differently, always supposing hydrogen to be present as well. We need only refer to the spectrum of aldehyde, which is inclined to be linear rather than banded, or rather the bands are bounded by absolute lines, and are more defined than when oxygen is more loosely bonded."

"An inspection of our maps will show that the radical of a body is represented by certain well-marked bands, some differing in position according as it is bonded with hydrogen, or a halogen, or with carbon, oxygen, or nitrogen. There seem to be characteristic bands, however, of any one series of radicals between 1000 and about 1100, which would indicate what may be called the central hydrocarbon group, to which other radicals may be bonded. The clue to the composition of a body, however, would seem to lie between λ 700 and λ 1000. Certain radicals have a distinctive absorption about λ 700 together with others about λ 900, and if the first be visible it almost follows that the distinctive mark of the radical with which it is connected will be found. Thus in the ethyl series we find an absorption at 740, and a characteristic band, one edge of which is at 892 and the other at 920. If we find a body containing the 740 absorption and a band with the most refrangible edge commencing at 892, or with the least refrangible edge terminating at 920, we may be pretty sure that we have an ethyl radical present. So with any of the aromatic group; the crucial line is at 867. If that line be connected with a band we may feel certain that some derivative of benzine is present. The benzyl group show this remarkably well, since we see that phenyl is present, as is also methyl. It will be advantageous if the spectra of ammonia, benzine, aniline, and dimethyl aniline be compared, when the remarkable coincidences will at once become apparent, as also the different weighting of the molecule. The spectrum of nitro-benzine is also worth comparing with benzine and nitric acid. . . . In our own minds there lingers no doubt as to the easy detection of any radical which we have examined, . . . and it seems highly probable by this delicate mode of analysis that the hypothetical position of any hydrogen which is replaced may be identified, a point which is of prime importance in organic chemistry. The detection of the presence of chlorine or bromine or iodine in a compound is at present undecided, and it may well be that we may have to look for its effects in a different part of the spectrum. The only trace we can find at present is in ethyl bromide, in which the radical band about 900 is curtailed in one wing. The difference between amyl iodide and amyl bromide is not sufficiently marked to be of any value."

The absorption spectra of the didymium and cobalt salts afford many striking examples of the complicated effects of solution and combination in the spectra. It is impossible to explain these without the help of illustrations, and we must refer the reader, therefore, to the original papers.[1] Some very interesting changes have been noticed in the position of absorption bands when certain colouring matters are dissolved in different liquids. Characteristic absorption bands appear for each colouring matter in slightly different positions according to the solvent. Hagenbach, Kraus, Kundt,[2] and Claes[3] have studied the question. In a preliminary examination Professor Kundt had come to the conclusion that solvents displaced absorption bands towards the red in the order of their dispersive powers; but the examination of a greater number of cases has led him to recognize that no generally valid rule can be laid down. At the same time highly dispersive media, like bisulphide of carbon, always displace a band most towards the red end, while with liquids of small dispersion, like water, alcohol, and ether, the band always appears more refrangible than with other solvents; and as a general rule the order of displacement is approximately that of dispersive power.

Relations of the Spectra of Different Elements.

Various efforts have been made to connect together the spectra of different elements. In these attempts it is generally assumed that certain lines in one spectrum correspond to certain lines in another spectrum, and the question is raised whether the atom with the higher atomic weight has its corresponding lines more or less refrangible. No definite judgment can as yet be given as to the success of these efforts. Lecoq de Boisbaudran has led the way in these speculations, and some of the similarities in different spectra pointed out by him are certainly of value. But whether his conclusion, that "the spectra of the alkalis and alkaline earths when classed according to their refrangibilities are placed as their chemical properties in the order of their atomic weight," will stand the test of further research remains to be seen. Ciamician[4] has also published a number of suggestive speculations on the question, and Hartley[5] has extended the comparison to the ultra-violet rays.

When metallic spectra are examined it is often found that some line appears to belong to more than one metal. This is often due to a common impurity of the metals; but such impurities do not account for all coincidences. The question has been raised whether these coincidences do not point to a common constituent in the different elements which show the same line. If this view is correct, we should have to assume that the electric spark decomposes the metals, and that the spectrum we observe is not the spectrum of the metal but that of its constituents. Further investigation has shown, however, that in nearly all cases the assumed coincidences were apparent only. With higher resolving powers it was found that the lines did not occupy exactly the same place. With the large numbers of lines shown by the spectra of most of the metals some very close coincidences must be expected by the doctrine of chances. The few coincidences which our most powerful spectroscopes have not been able to resolve are in all probability accidental only. (A. S*.)

SPEECH-SOUNDS, the sounds actually used for the conveyance of thought by speech. See PHONETICS.

1. *Symbolization.*—It is necessary to have some system of writing speech-sounds, in order to talk of them. The system used in the present article is the palaeotype of the present writer's *Early English Pronunciation*. All letters or words thus written will be enclosed in (). The following preliminary list of the ordinary sounds, with examples, will render what follows intelligible. For an alphabetical list, see art. 20.

English.—1. *beet bait baa bought boat boot* (biit bet baa BAAt boot but). 2. *knit net gnat knot nut nook* (nit net næt not nut nuk). 3. *file foil fowl fuel* (fa'il fɔ'il fa'ul fiuu'il). 4. *hay* (hee). 5. *pea bee, toe doe, cape gape* (pii bii, *too* doo, kɛɛp gɛɛp). 6. *whey way, feel veal, thin then, seal zeal, rush rouge, hue you* (whee wee, fiil viil, thin dhen, siil ziil, rosh ruuzh, jhiuu juu). 7. *ear ring, gull little* (iir riq, gel lit'l). 8. *sum chasm, sun open*, sung (sam kæz'm, san oop'n, saq). 9. chest jest (tjest djest).

Foreign.—F French, G German, IT Italian. 10. *bête* F, *lache* F, *no* IT, *dd* F, *feu* F, *veuf* F, *vin* F, *vent* F, *vont* F, *un* F, *soin* F, *soi* F, *lui* F (bɛɛt, laash, no, dyy, fø, vœf, vɛa, vaa, voa, œa, siiɛa, siia. lyi). 11. *dach teich*, tage siege, wahl, all G (dakh taikjh, taaghw, ziigjhw, bhaal). 12. *paglia* IT, *besogne* F (pa'ljà, bəzonj).

2. *Nature of Speech-Sounds.*—Speech-sounds result from shocks given to the air by the organs of speech, received by the drumskin of the ear, and transmitted to the auditory nerves in the cochlea. The apparatus is explained by Helmholtz, who deals with musical sounds. But speech is not musical, and its sounds are much obliterated when rendered musical.[6] An original quality of tone generated by the vocal chords is modified by the cavities through which it passes, as explained by Helmholtz (*Sensations of Tone*) on the principle of resonance. There are three ways in which speech-sounds may be produced—(1) by the air in the mouth, without additional breathing, by smacks and clicks; (2) by drawing in air, as orally in chirps, whistles, sobs, gasps, and nasally in snuffles, snores; (3) by expelling air, as in the greater number of speech-sounds. The last are

[1] Measured by Thalén. [2] Measured by Liveing and Dewar. [3] *Phil. Mag.*, xiv. p. 419 (1857).

[4] *Phil. Trans.*, part ii. (1885). [5] *Phil. Trans.*, iii. p. 887 (1881).

[1] Bunsen, "On the Inversion of the Bands in the Didymium Absorption Spectra," *Phil. Mag.*, xxviii. p. 246 (1864), and xxxii. p. 177 (1866); Russell, "On the Absorption Spectra of Cobalt Salts," *Proc. Roy. Soc.*, xxxii. p. 258 (1881). [2] *Wied. Ann.*, iv. p. 34 (1878). [3] *Wied. Ann.*, iii. p. 389 (1878).

[4] *Wien. Ber.*, lxxviii. (1878). [5] *Journal Chem. Soc.*, September 1883. [6] Ellis, *Speech in Song*, sect. iv.

either *flated*, the vocal chords being wide apart and hence not vibrating, but allowing breath to pass freely, or *voiced*, the vocal chords being close together and vibrating fully, or else *whispered*, the vocal chords approximating but not touching, and their edges only vibrating. The last is only a variation of the second and needs no further consideration. Flated and voiced sounds are either *fixed*, the position of the vocal organs remaining unchanged throughout, or *changing*, the position constantly altering from one fixed position to another, forming "glides."

3. *Generic and Specific Speech-Sounds.*—Fixed speech-sounds, intended to be the same, vary from speaker to speaker, and in the same speaker at different times. Those who attempt to write sounds from dictation rapidly find that they have to disregard these specific differences, and simply discriminate genera. And much difference of opinion has always existed as to the discrimination and number of genera.

4. *Vowels*, that is, *vocals*, are so called because their positions allow the voice-sounds to pass with least obstruction. The three genera (ii, aa, uu), which have always been distinguished, differ greatly in the positions of the tongue and lip, that is, in their mouth cavities, and hence resonance. The usual method of describing speech-sounds is by the shape of the cavity, which, however, could be shown to be insufficient for many reasons. As differently shaped cavities resound to a note of the same pitch, Helmholtz proposed the last for discrimination. The pitches of (ii, aa, uu) are widely different, (ii) having the highest and (uu) the lowest; but the extreme diversity of results in attempting to assign the actual pitch of vowel cavities shows that this will not suffice. Resonance cavities do not create but merely modify original vowel qualities of tone, and these last seem to depend upon the will of the speaker, guided by his powers of appreciation and imitation, both extremely variable, partly hereditary, partly depending on conformation of brain, and partly acquired during adolescence.

Melville Bell, Sweet, Storm, and Sievers, and all who have latterly examined the subject distinguish at least two series of vowel genera, that is, two forms of each genus, called "narrow" and "wide"; but they are far from being agreed as to what the difference consists in and how it is produced. Sweet differs from Bell, and Sievers does not wholly agree with Sweet. All, however, call (ii, uu) narrow, and (*i*, *u*) wide.

Besides these two series Bell introduced another distinction applying to both, termed "rounding," consisting in a greater or less closure of the lips, slight for (ᴀᴀ), much for (uu), and intermediate for (*oo*). But this character is not scientifically precise, because all the vowels can be produced with the mouth wide open (by means of a compression of the arches of the palate), and still more easily with the mouth at least as much closed as ordinarily for (uu). Other phonetists wish to introduce distinctions based upon the shape of the apertures between the lips.

There is also a feeling of intermediateness between vowel-sounds. Thus (yy) is felt by many to lie "between" (ii, uu), and (œœ) between (*oo*, *ee*). But we also have other intermediates which arise spontaneously when listening to new languages and dialects. Thus in west Somerset there is a vowel between (ə, i), one between (y, ɘ), and another between (ɘ, œ), and the positions for these vowels have not been ascertained. These are only specimens of numerous cases. Hence the positional discrimination breaks down at present. Nevertheless it is very good so far as it goes, but must not be pressed to extremes.

All the vowels may be also flated and whispered; that is, the position and dictating vowel-intention remaining, the totally or partially open vocal chords forbid voice and produce sound more or less recognized as substitutes for the true vowels. Write (ii) voiced, ('ii) whispered, ("ii) flated. This distinction becomes of more importance for consonants.

5. *Glottids and Physems.*—A *glottid* is the action of the vocal chords in altering the form of the *glottis* or tongue-shaped space between them. (1) The glottid is *clear* when there is no attempt to utter the vowel until the chords are brought together, yet the utterance takes place at that instant. This may be written (,ii) initial. Similarly, a vowel may end with a clear glottid (,ii,), no flatus escaping after the vowel ceases. This clear glottid is usually inferred and not written. (2) The glottid is *gradual*, written (ɪ), when flatus passes through the vowel position before the chords are sufficiently approximated for voice, or after they are separated, thus (ɪiiɪ) is really ("ii + 'ii + ii + 'ii + "ii). This is an exceedingly common habit with some speakers. (3) The *check* glottid (;), Arabic *hamza* ء, arises from keeping the chords tightly closed so that they cannot vibrate, and then releasing them with an explosion. It may be final in reverted order in Arabic, and it is common as an initial in German, as *;eine ;er;innerung*, and is used as the *catch* accent in Danish, as *ma;nd*, a man, distinct from *man* = F *on*. (4) An exaggeration of (;) gives Arabic (ɡáin) ع, the bleat, with a rattle in the cartilaginous glottis.

Physems are the bellows-actions of the lungs. (1) The jerk (ʜ) or sudden puff of either vocalized or flated breath, accompanying either clear or gradual glottid. The first, with voice only, is the singer's and Bengali aspirate; the second, with flatus, is the Scotch or German aspirate. (2) The *wheeze* (*h*), Arabic ح, stated by Czermak to arise from suddenly forcing breath through the cartilaginous glottis.

6. *Vowel Glides and Vanishes.*—So far the positions of the vowel above the larynx have been supposed to remain unchanged. In this case many degrees of length may be distinguished, as (ă) very short, (a) short, (à) medium, (aa) long, (aà) drawled, (aaa) extravagantly prolonged If the vowel sign consists of two parts, as (ah), only the first is marked doubled or tripled for these lengths, as (ăh, aah), &c. In English it is felt very difficult to preserve the positions for long (*ee*, aa, *oo*), and these vowels gravitate to, without by any means reaching, (i, ə, u). The first and last may be written (*ee*'j, *oo'w*), implying what are termed *vanishes* or gliding alterations of sound, accompanied by alterations of position as the vowel ceases. This change is generally unintended and mostly used unconsciously.

7. *Diphthongs.*—But there are conscious changes to quite different positions. The first and last vowels are then taken as fixed, one of them having the chief stress, and there is a vowel glide between them. These form *diphthongs*; the stress and glide being the chief characteristics are marked by ('), and the two elements are juxtaposed. The glide is generally short and close in English, longer in German, still longer and looser, or "slurred," in French and Italian. There are many typical classes. i. With weak final (i), unanalysed (a'i), analysed (ái, á*i*, ə'*i*, ɪ'*i*, é*i*, é*i*, ᴇ'*i*, æ'*i*), &c., all common. ii. With weak final (u), unanalysed (a'u), analysed (áu, á*u*, ə'*u*, ɪ'*u*, é*u*, é*u*, ᴇ'*u*, æ'*u*), &c., all very common. iii. Weak final (y), theoretic German *eu* (óy, áy), Devonshire *ow* (æ'y$_1{}^5$). iv. Weak initial (i) or (ĭ), used for (ɹ) in Italy, France, Wales, &c. v. Weak initial (y) in Fr. vi. Weak initial (u) or (ŭ), used for (w) in Italy, Spain, France, Wales, &c. vii. Murmur diphthongs ending in weak (ɐ), common in English, but generally with the option of trilling an (r) after it, and hence written (ɹ), as in *ear*, *air*, *oar*, *lord*, *poor*, *pure*, *pyre*, *power* (*ii*ɹ, eeɹ, ooɹ, lᴀᴀɹd, puuɹ, pĭ*uu*ɹ, pa'*i*ɹ, pa'uɹ); the *r* is always trilled in Scotland. viii. The vanish diphthongs (*ee*'j, *oo'w*), just considered. ix. Inchoant diphthongs, first *grave*, where the speaker begins too low and corrects himself, as (*ĭ*i, *ŭ*u), and secondly *acute*, where he begins with the mouth too open and corrects himself as he proceeds, as (ɪ'*o*); both are common in English dialects.

8. *Glides from and to Mutes, Post-Aspirates, Sonants.*—The essence of the diphthongal character was the glide, which was independent of the sounds of the first and last elements. These might be absolutely mute, as in (piip, tᴀᴀt, k*oo*k) peep, taught, coke, in which (p, t, k) are mere positions without sounds. But the results are quite different from (ii, ᴀᴀ, *oo*), because while the consonant positions are opened out the vowel is at the same time sounded. Similarly in the reverse order, when final. But here the enclosure of the breath is felt to be uncomfortable, and, if there is no vowel to fall upon, the mouth is opened and a puff of flatus ('), called the "recoil," is heard in England, as (piip') peep! Using then (+) for the gliding sounds, we have (p + ii + p + '); but there is no recoil in (p + ii + p + *i* + q) or (p + ii + p b + *oo'w*!) peeping, peep-bo! Various nations have very different habits in this respect. In Indian languages (p') would be felt as a final post-aspirated mute. So initially in Germany, the (p) position is usually released, not on a vowel with a clear glottid, as in England and Italy, but on a vowel with a gradual glottid, as (pɪii), and hence flatus is heard before the vowel. When this is exaggerated, as (pɪhii) or (pʜɪhii), we have the true Indian post-aspirated mute.

But an attempt to utter the vowel through a mute position may be made before the position is quite opened out, or the vowel may be continued into it after it has been assumed. This gives the English, Italian, and Indian "sonant," as in (b*ee*b) babe. The German is not quite the same. Here the glides are (b + *ee* + b), with possibly a voiced recoil (b + *ee* + b + '), where (') represents the most amorphous voice. This voiced recoil is strong in French, but seldom heard in English, except in declamation, is regular in modern Indian, and impossible to a German, who says at most (b*ee*bp') or (b*ee*p'); also Indians and Irish sometimes jerk out their vowel after sonants, as (bʜ*ee*bʜ'), producing the sonant post-aspirates. The ancient Indian never ended words in the pause with sonants, post-aspirated mutes, or post-aspirated sonants, but only with simple mutes, and avoided the recoil.

9. *Glides to and from Hisses, Buzzes.*—In the case of a hiss, flatus passes through the consonant position and is continued part of the time during which the vowel position is assumed, but towards the end of that time voice is put on. Hence in (s + ii) see, the glide (+) is partly flated and partly voiced, so that (s) acts in much the same way as a gradual glottid; similarly when final, as (s + ii + s) cease, where the hiss replaces the recoil. But the proportion of voice and flatus in the glide may vary. The voice may be put on during the hiss, and then the change takes place in the hiss position. The result, far less clear than a vowel, is a hiss (s), followed without a positional glide by the buzz (z), then an entirely vocal glide, the vowel, and a vocal glide, a buzz, and a hiss, as (sziizs) seize, sees. The initial (sz) is regular in Germany, where no vowel precedes, as *sie sehen* (szii *zee*'n), they or you see; and the reverse (zs) is regularly in English seize (siizs) in the pause, and similarly (haavf, briidhth, ruuzhsh, dɟədɟshj) halve, breathe, rouge, judge. In the south-west of England Saxon words beginning with *s*, *f* are pronounced with (z, v) initial, which passes through (sz-, fv-) to (s, f).

10. *Glides to and from Flaps.*—Flaps are consonants where there is a slack organ which flaps with the breath as it passes. The *r* is very varied, but properly voiced, though the flated form occurs. The flap may be made (1) with the lips, as (brh), used in Germany to stop horses; (2) with the tip of the direct tongue, (r, ,r), used in Italy; with the tip of the reverted tongue, (ʀ), used in the south of England and in modern (not ancient) Indian, where it is called "cerebral"; (3) with the uvula, (*r*), common in France and north Germany, labialized (*rw*) in Northumberland, and harsher in Greek and Arabic; (4) with the glottis, (ɪ), usual in Denmark; and so on. In the educated south of England the tongue is often raised to the (r) position, but not allowed to flap, and is treated as a buzz (r̥).

The above form the *central* flaps; if the point of the tongue is fixed and the voice escapes by the side it causes minute *lateral* flaps of the tongue. The place of the point of the tongue discriminates the various sounds which differ but slightly—(l̩), advanced tongue at gums, Continental; (l), coronal, tongue near the crown of the palate, English; (ʟ), reverted, in connexion with (ʀ) in south-west England.

Both flaps, especially the latter, are extremely vocal, and the glides from and to them are like those from and to vowels, while they glide readily to and from mutes, sonants, hisses, and buzzes.

11. *Glides to and from Hums, Orinasals.*—For (p, t, k) both nasal or oral passages are cut off, the former by pressing the uvula against the back of the pharynx. Let this pressure be relaxed so that the nasal passage is opened, the oral passage remaining closed. The voice passes through the nose, forming the three hums (m, n, q). The glide from these to ordinary vowels is the same as from (b, d, g), and the peculiarity consists in the preceding hum and the closing of the nasal passage as the vowel position is assumed. If the nasal passage is left open at all the vowel is "nasalized," and as it resounds partly in the nose and partly in the mouth it becomes an "orinasal." Four principal orinasals exist in French, as *an*, *on*, *un*, *vin* (aᴀ, oᴀ, œᴀ, veᴀ); there are more in Portuguese, and many others in the modern Indian languages. The oral vowel is altered in character by nasalization, and it is not possible to assign the oral to the orinasal form precisely. If the oral passage is only slightly open, a "nasalized tone" is produced, as in Gaelic, some south German, and American dialects, written as (a̜). The hum also may be prolonged, and ('mpaa, 'mbaa, 'ntaa, 'ndaa, 'qkaa, 'qgaa) result. These forms exist in South African languages.

The final hum may be continued like a vowel. If the nose entrance is closed and the voice continued (l*i*m, læm, k*oo*m) become (l*i*mb, læmb, k*oo*mb), which, as the ordinary spelling shows, were probably once pronounced. But not only the nasality, the voice itself may be cut off, and then we have the mere stops (p, t, k), thus (l*i*mp, l*i*nt, l*i*qk), which in the pause have the recoil. Some phonetists consider (m, n, q) to become flated in this case; as (mh, nh, qh). This is no more necessary than to suppose a vowel to be flated before a mute, so that (læp, mæt, hæk) lap, mat, hack should be (l"æp, m"æt, h"æk), a usage unknown.

12. *Palatalization and Labialization.*—When a consonant precedes a diphthong of classes iv, v, vi, in art. 7 beginning with weak (i, y, u), there is a tendency to take these vowels as nearly as possible simultaneously with the consonant, expressed by writing (j, *w*j, *w*) after the consonant. To say (tj) at least two-thirds the length of the tongue from the tip backwards must lie against the palate, for (kj) two-thirds from the root forwards. The first occurs in Hungarian; the second was very common among older speakers of English before (æ), as (kjænd'l). Both (tj, kj) are apt to develop into (tɟ); compare *nature*, *kirk*, say (n*ee*tjɐɹ, kjəəɹkj), with colloquial modern (n*ee*tɟɐ, tɟəətɟ). Similarly the voiced sounds (dj, gj) become (dɟ), compare *rig*, *ridge*. These (tɟ, dɟ) are consonantal diphthongs = (tjshj, djzhj), as in *ch*est, *j*est, and are distinct from the Indian sounds (kɟ, gɟ) च, ज, which are true mutes, produced by bringing the tongue from

the position for (J) tight up against the extreme back of the hard palate so as to produce a complete stop. The most important of the palatalized letters are (lj, nj), the Italian *gli*, *gn* in *miglior*, *ognor* (miljò·r, ònjò·r), where the palatalization brings the Italian advanced (,l, ,n) to the position of the English (l, n). The (lj) has degenerated to (ĭ) or (J) in France during the 19th century. It exists in Spanish *ll*, Portuguese *lh*. The (nj) exists as *gn* in French, *ñ* in Spanish, and *nh* in Portuguese.

Parallel to the palatal are the labial forms, of which English *queen*, *guano* (kwiin, gwaa·no) are examples. They seem to exist in abundance in French, as in toi, doigt (,twa, ,dwa). The palato-labial form (wj), as in *juin* (zhwjeʌ), is much disputed, and a diphthong (zhyéʌ) is usually assumed.

13. *Syllables.*—A group of speech-sounds increasing in volume from a mute, sonant, hiss, buzz, or flap to a full vowel and decreasing again to one of the former constitutes the ideal-syllable (συλλαβή, collection). The initial and final parts may sink to clear glottids, and the middle part to a simple vowel. The type of a syllable is then < >, crescendo followed by diminuendo, as in (,aa, ĭaaĭ, tĭaaĭt‘, stĭaaĭts), theoretical, and (dɟədɟd, streqkth, twelfths), actual syllables. The hisses or recoil before or after a stop are not felt as belonging to fresh syllables, because they have no vowel, which is the soul of the syllable. Monosyllables present no difficulty, but the division of syllables in polysyllables is not easy to understand. In (pii + p + iq) the middle (p) ends one set of glides and begins another. One syllable ends and the other begins with the ássumption of the (p) position which is absolutely mute, so that the end of the first and the beginning of the second syllable are simultaneous, as the end of one hour and the beginning of the next. In this case (p) is said to be "medial." But there may be and often is a sensible pause between the two syllables, and then (p) is said to be "double," as (pii + pp + iq, piippiq), in which case no recoil can be used, as (piip‘piq). In "syllabizing," a totally artificial process, doubling is necessary, and very frequently the recoil is used, but it never is in speech. In (sii + s + iq) ceasing, there is a sensible hiss between the glides which end the first syllable and those which begin the second, and the syllable divides during that hiss. If we wished to produce the effect of doubling, we must break the hiss into two either by a silence or a diminution of force, as (missent). The same remarks hold for sonants, buzzes, and flaps, where we have a sensible voice sound during which the syllable divides. Syllables may even divide during a vowel, as French *payen*, *fayence*, *vaillant* (paĭeʌ, faĭaʌs, vaĭaʌ), where the syllable divides during (ĭ), which may even be lengthened to show the two syllables; but, if the syllables have to be sung to notes with a pause between them, we must double the (ĭ), thus (paĭ ĭeʌ, faĭ ĭaʌs), as either (paĭ eʌ, faĭ aʌs) or (pa ĭeʌ, fa ĭaʌs) would be unintelligible. The sensation of separate syllables is always easy. It is the essence of versification, the oldest form of literature.

14. *Accent and Emphasis.*—Generally several syllables form a single word, and in many languages—by no means all languages—one syllable in a word is rendered conspicuous. Several plans have been adopted for this purpose. (1) Quantity or length of syllables, which seems to be all that is known to modern Indians, Arabs, and Persians. (2) Heightened or lowered or descending gliding pitch (*con portamento*) of one syllable, which were the acute, grave, and circumflexed syllables of Sanskrit, Latin, and Greek, the position of these syllables in a word there depending partly on the quantity of the syllables and partly on sense; this pitch difference remains in a more complicated form in Norwegian and Swedish. (3) Greater force given to one syllable; this is the English, German, and Italian "stress," and from the end of the 3d century A.D., when the feeling for quantity faded, was used instead of high pitch in Latin and Greek. The modern Italian and modern Greek as a general rule preserve the memory of the syllable which had the high pitch by giving it greater force, with but few exceptions, as Italian *cade·re ri·dere*, to fall, to laugh. (4) By a peculiar pronunciation, as the "catch" of the Danes. In French none of these methods seem to be consciously adopted. Some declare that the last syllable (not counting mute *e*) *always* has the stress, others that it *never* has the stress; others, again, consider the stress to be intentionally even, and when altered to depend mainly on grammatical construction, while there is certainly a raised pitch, frequently towards the close of a phrase or sentence, but sometimes on a penultimate syllable. Turks and Japanese have also even stress. All these modes of rendering a syllable conspicuous are apt to be called "accent," the Latin translation of προσῳδία, the song added to the word, which properly applied to class (2) only. Where pitch accent prevailed there may have been also stress, but that stress was probably as little subject to strict rule as alteration of pitch is in English speech, where it undoubtedly exists, without properly affecting signification. Hence we may say roughly that in Latin and Greek pitch was fixed and stress free, but in English and German stress is fixed and pitch free.

What accent is to a word, emphasis is to a sentence. But there is this difference. Accent always falls on a fixed syllable of a word. Emphasis varies with the word to be made conspicuous. Emphasis does not consist merely in making the stressed syllable of a word louder. It depends upon a number of most subtle varieties of qualities of tone, length, and pitch of utterance,—in short, of those tricks and wiles of speech which form the stock-in-trade of actors and orators. The same words will mean totally different things according to the place and nature of the emphasis used. Different nations emphasize differently. To an Englishman French emphasis is apt to seem placed on the wrong word.

15. *Intonation.*—Although musical accent does not exist in English, almost every county has its peculiar sing-song mode of utterance. And even among educated men the sing-song may frequently be heard in public speaking, or in declaiming poetry, or recitation, or reading aloud generally. For these things no invariable rule exists. But in England questions require the pitch of the voice to be raised, and affirmations to be lowered, towards the end of a clause. In Scotland the pitch is raised in both cases, so that to an Englishman a Scotchman seems to be always asking questions.

16. *Analysis of Speech-Sounds.*—What is heard are sentences consisting of various fixed sounds cemented by gliding sounds, which act one on the other, and thus become greatly modified. To construct an alphabet it is necessary from this mass to separate the fixed elements and the changing glides, to crystallize them into symbols, and finally to make the value of those symbols known to the reader. The last cannot be done satisfactorily except by *viva voce* instruction, but much can be accomplished by a review of the relations of sounds, made dependent on the relations of the motions of the organs of speech by which they are produced. There is a preliminary difficulty in defining an element. Perhaps position, flatus, whisper, and voice are the only ultimate elements. But it is usual to be very lax. Thus (p,'t, k) have position only, (f, s, sh, kh) position and flatus, (i, a, u, w, z, zh, gh) position and voice. The analysis is therefore only into "proximate" and not "ultimate" elements. Again, when a new mass of sound is presented to the ear, a long time passes before the ear becomes sufficiently accustomed to the sound to distinguish the proximate elements and their combinations, and therefore before the voice can imitate them at all satisfactorily. Hence the best phonetists differ. It may certainly be considered impossible from a knowledge of a few languages to onstruct an alphabet which will serve for all. Nevertheless a consideration of some partial schemes is of great value as a stepping-stone. We give Mr Melville Bell's vowel system and Mr Henry Sweet's alteration of Mr M. Bell's consonant system, both supposed to be universal, but neither properly appreciating Asiatic, African, and American-Indian languages and habits of speech. After these follows a modification of a confessedly partial system by the present writer, applying chiefly to English, German, Italian, Spanish, and French, with a few partly theoretical sounds, introduced to show connexions. In all these the sounds will be expressed by palaeotype symbols without any explanation in the tables themselves, because that is furnished at better length than would there be possible in the alphabetical list of art. 20.

17. *Mr Melville Bell's "Visible Speech" Vowels.*—These are arranged primarily according to the height of the tongue, which is supposed to be divided into "back" and "front" or central part, beyond which lies the "point." The heights refer first to the "back" and lastly to the "front," and between them lie the "mixed," for which both back and front are more raised than the "front," so that there is generally a hollow between them. Each set is then divided into "narrow" and "wide," the precise meaning of which, as stated in art. 4, is not settled. Finally come the "rounded" vowels, there being three degrees of rounding,—one for "high," one for "mid," and one for "low" tongue. For convenience here the back, the mixed, and the front are formed into separate groups, and all the vowel signs are numbered, being referred to in the following lists by V and the number, thus V4 is (*u*), which in Mr Bell's nomenclature would be called "high-back wide-round." The letters *n*, *w*, *nr*, *wr* at the heads of columns mean "narrow, wide, narrow-round, wide-round."

Mr. Melville Bell's "Visible Speech" Vowel Table.

Tongue Height.	Tongue Back.				Mixed.				Tongue Front.			
	n.	*w.*	*nr.*	*wr.*	*n.*	*w.*	*nr.*	*wr.*	*n.*	*w.*	*nr.*	*wr.*
High..	1 œ	2 ɐ	3 u	4 *u*	13 ʏ	14 *y*	15 ʊ	16 *u*h	25 i	26 *i*	27 ɪ	28 y
Mid ..	5 ɜ	6 a	7 *o*	8 o	17 ə	18 ah	19 *o*h	20 oh	29 *e*	30 e	31 ɘ	32 œ
Low ..	9 Œ	10 *a*	11 ʌ	12 ɔ	21 əh	22 ꝏ	23 *a*h	24 ɔh	33 ᴇ	34 æ	35 əh	36 æh

These positions being insufficient, although supposed to be precisely known, may be "modified" by raising the tongue more (a^1) or lowering it more (a_1), or bringing it nearer the teeth (,a) or nearer the throat (a,). And, even this not sufficing, Mr Sweet has contrived a number of new modifiers, here passed over. And with all this none of the sounds can be produced purely through any position without an effort of will dependent on a conception of the sound. The characteristic of the vowel notation contrived by Mr Bell is that each sign shows at once the position of the sound in the Table.

18. *Mr. Henry Sweet's "Sound Notation" Consonant Table.*

	a. Tongue Back.	*b.* Tongue Front.	*c.* Tongue Point.	*d.* Point Teeth.	*e.* Blade.	*f.* Blade Point.	*g.* Lips.	*h.* Lip Back.	*i.* Lip Teeth.
	Voiceless Consonants.								
1. Open ..	kh	Jh	r,h	th	s	sh	ph	wh	f
2. Divided	lh	lJh	lh	,lh	..	..	ph_1	..	..
3. Shut ..	k	kJ	t	,t	..	..	p	..	..
4. Nasal ..	qh	qJh	nh	,nh	..	..	mh	..	..
	Voiced Consonants.								
5. Open ..	gh	J	r.	dh	z	zh	bh	w	v
6. Divided	l	lJ	l	,l	..	..	bh_1	..	..
7. Shut ..	g	gJ	d	,d	..	..	b	..	..
8. Nasal ..	q	qJ	n	,n	..	..	m	..	..

These signs will be referred to as S 8 *c*, or Sweet, line 8, col *c*, giving (n). The consonants are modified in a similar manner to the vowels. Columns *a*, *b*, *c* indicate straits or contacts between the palate and the parts of the tongue named. By the "blade" is meant the part of the tongue between the "front" and the "point." Mr Sweet's substitutes for glottids and physems, and his and Mr Bell's notation of glides are omitted for brevity. Their notation throughout is entirely different from that here used.

19. A. J. Ellis's partial schemes, modified from his *Speech in Song.*

Vowel-Trigram.

1 i	2 *i*	3 *e*	4 e	5 ᴇ	6 æ	7 ah	↘
..	16 y	17 ɘ	18 œ	19 ɐ	20 ə	21 ɜ	—8 = 22 a
15 u	14 *u*	13 *o*	12 o	11 ɔ	10 ʌ	9 *a*	↗

The meaning of this arrangement is that, if we pronounce the vowels in the order of the numbers, they will form a sufficiently unbroken series of qualities of tone, or, if each line be so pronounced leading to 8 = 22 a, three series of the same kind are produced, and also that the speaker feels that the vowels in the middle line lie "between" the vowels in the first and third lines between which they are written. These intermediate characters refer only to qualities of tone and not to the vowel positions, as they apparently did in the older "vowel triangles" from which the trigram is adapted. The arrangement of Mr Bell is excellent for showing the relations of the positions, but gives no more clue to the relations of sound than the indispensable ratios 1 : 2, 2 : 3, 3 : 4, 4 : 5, 5 : 6 give to the musical sensations of the intervals known as the octave, fifth, fourth, major third, and minor third. Hence the advantage of this additional arrangement. It will be referred to as T 6, that is, trigram, vowel 6, or (æ).

Consonant Table.

Classes.	Contacts or Straits formed by	1 (I. Tongue Back and) Uvula.	2 Soft Palate and Lips.	3 Soft Palate only.	4 (II. Tongue Front and) Back with Palate.	5 Palate only.	6 Point with Palate.	7 (III. Tongue Point) Reverted with Palate.	8 Direct with Palate.	9 Direct with Gums.	10 Direct with Teeth.	11 (IV. Lips) with Teeth.	12 Flat.	13 Round.
	ORAL. CONTACTS.													
i	Mute ..	K	kw	k	kj	kJ	tj	T	t	,t	..	P	p_1	p.
ii	Sonant ..	G	gw	g	gj	gJ	dj	D	d r.	,d	..	B	b_1	b.
	STRAITS. *Fixed.*													
iii	Flated ..	..	kwh	kh	kjh	Jh	sj	sh	shj	s ,s	th, th	f	ph	wh
iv	Voiced ..	..	gwh	gh r.	gjh	J	zj	zh R.	zhj	z ,z	dh, dh	v	bh	w
	Flaps. Central.													
v	Flated ..	..	..	krh *r*h	..	..	..	..	rh	,rh	..	..	..	prh
vi	Voiced ..	..	*r*w	grh *r*	..	..	..	R	r	,r	..	..	ĸ	brh
	Lateral.													
vii	Flated ..	..	..	..	..	..	..	Lh	lh lsh	,lh	..	..	..	..
viii	Voiced ..	..	..	..	..	..	lj	L	l ls	,l	..	..	..	..
	NASAL.													
ix	Flated ..	..	..	qh	..	..	..	..	nh	,nh	..	..	..	mh
x	Voiced ..	..	..	q	qj	qJ	nj	N	n	,n	..	..	..	m

This table will be referred to as C iv 7, or consonant table, class iv, column 7 = (zh). The glottids and physems are sufficiently explained in art. 5, and are here omitted.

20. *Alphabetical List and Explanation of the Palaeotype Symbols.*—Small letters, italics, small capitals, and the forms resulting from turning them must be sought under the large capital of the same class, where the order of all the letters is specified. Explanations are greatly condensed and often confined to references to the preceding articles and tables, or to an example. The notation for differences of length is explained in art. 6.

Abbreviations.

- AR. Arabic.
- B. Melville Bell.
- C. A. J. Ellis's consonant table (art. 19).
- DN Danish.
- E. A. J. Ellis.
- E. English.
- F. French.
- G. German.
- IT. Italian.
- LLB. Prince Louis-Lucien Bonaparte.
- LS. Lowland Scotch.
- MG. Modern Greek.
- OCC. occasionally.

Abbreviations.

- PL. Polish.
- PR. Portuguese.
- S. Sweet's consonants (art. 18).
- SN. Sanskrit.
- SP. Spanish.
- St. Storm.
- Sv. Sievers.
- Sw. Sweet.
- SWD. Swedish.
- T. A. J. Ellis's vowel trigram (art. 19).
- V Bell's visible speech vowels (art. 17).

A. (a ah a'i a'u aʌ a'y, a^1, *a* *a*h, ʌ, ɐ).

(a) V 6, T 8 = T 22, short G m*a*nn, long E f*a*ther, art. 6.
(ah) V 18, T 7, occ. E p*a*ss, p*a*th.
(a'i) art. 7 i, unanalysed diphthong, E *eye*, G *ei*.
(a'u) art. 7 ii, unanalysed diphthong, E h*ow*, G b*au*.
(aʌ) art. 11, F v*en*t, a conventional form.
(a'y) art. 7 iii, unanalysed G fr*eu*de, often (ɔ'*i*).
(a^1) or (a) with higher tongue, IT and F short *a*, nearly = (əh).
(*a*) V 10, T 9. B. hears it in E f*a*ther, *a*rms, *a*lms; E. does not. Sw. and E. hear it in LS f*a*ther, E. and LLB. in F di*a*ble, E. in F p*â*te, p*a*s.
(*a*h) V 23. B. says (ʌ) with advanced tongue = (,ʌ), (ʌ) on the road to (a).
(ʌ) V 11, T 10, short open in E *au*thority, long closed E *au*l, almost peculiarly E.