HECTOR ON SCIENCE

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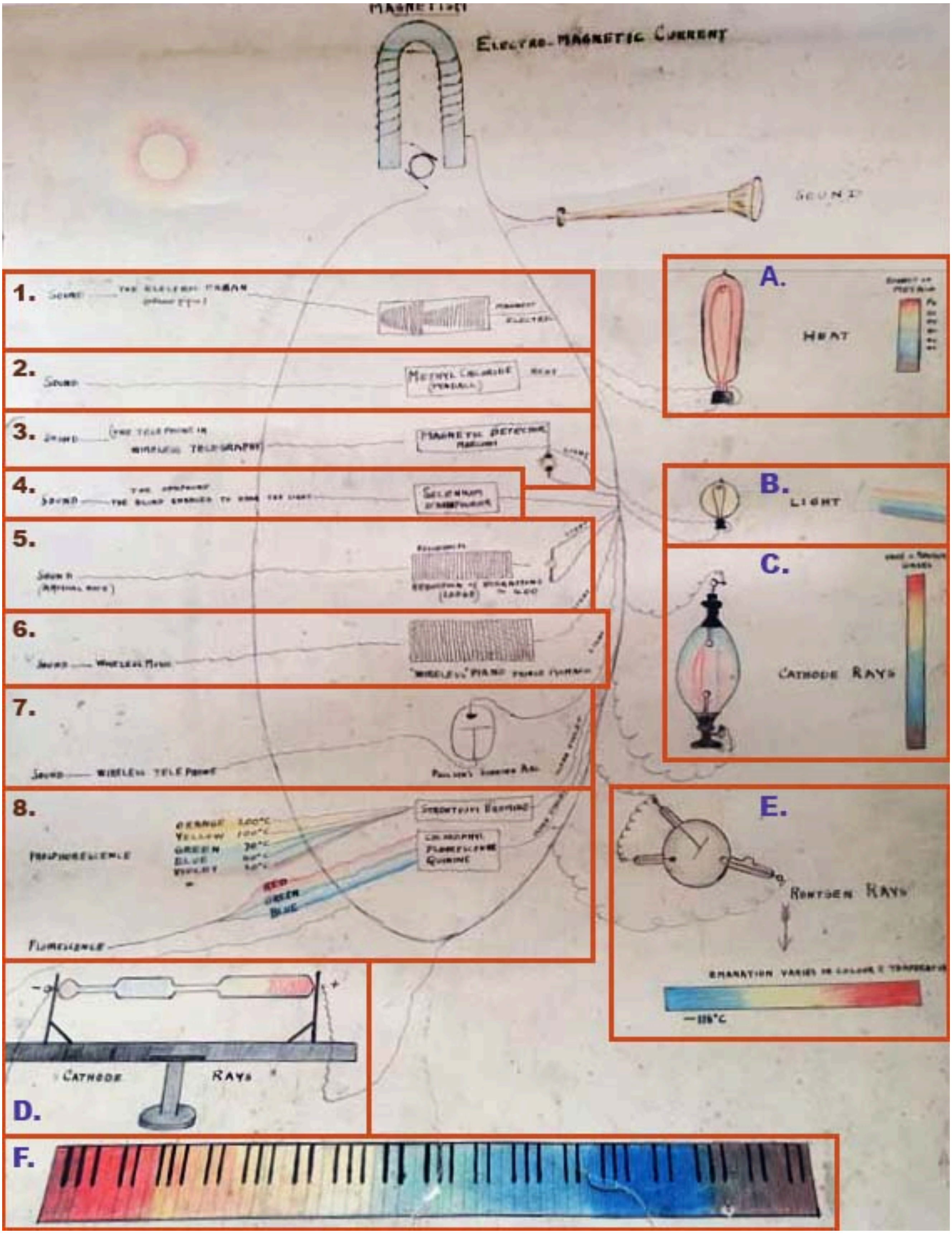
MAGNETISM



A B Hector, "MAGNETISM", illustration of some scientific ideas, c.1925-30
colour pencil and ink on paper, c.110 x 67 cm
Mitchell Library, State Library of New South Wales

Alexander Burnett Hector gave colour-music concerts with acoustic musical instruments, electrically attached to a coordinated lighting display. It is clear he saw his invention as having a wide relevance to contemporary science, and some capacity to embrace advanced technology.

Hector believed that sound, heat, light, cathode rays and X-rays were all products of the interactions between an electric current and a magnet, and all obeyed the same physical laws. To reinforce the unity of colour music, he blurred the distinction between sound and light. As outlined in his British patent GB191229615A, of 1912:
"It has been frequently stated that sound differs from light in so far as light will pass through a vacuum, but sound will not. This is only a partial statement of facts, as if the vacuum is perfect, neither sound, heat, light nor any other electrical phenomena will be transmitted therethrough."
That the speed of light in a vacuum is one of the universal constants of physics seems to have escaped Hector's notice.

1. SOUND

As well as a piano or pianola, Hector used a harmonium (referred to as an American organ). It is a small pneumatic organ, air being pumped with foot pedals through reeds to producing sound without pipes. It was not, however, the 'electric' organ mentioned in his drawing.

The magneto, mentioned on the right, was the first practical generator of electrical current. Hand-cranked telephones used a magneto to ring the operator. By the end of the 19th century, some machines produced wholly electrical music that could be transmitted over telephone wires.
One of the earliest electric organs was Georges Désilets's Wireless Organ of 1914. A musical note was created without pipes or reeds, when electrical sparks fired at calculated frequencies; their impulses were transmitted by radio waves to receiving antennas.
Lee De Forest's Audion Piano of 1915 created a great variety of musical sounds. The triode valve he invented could detect and amplify radio signals. It became a necessary component of radio receivers, found in many homes by the late 1920s.
By 1929, sophisticated electric organs by Coupleux and Givelet were capable of broadcast, so "an organist could play the organ...perfectly to the borders of Japan".

For colour music, Hector was indifferent to electronic music, but interested in broadcasting. *"By this means a series of wave lengths could be flashed Into Space, and simultaneously a series of individual organs In different centres would burst Into music, and Into coloured harmonies of light"*, as reported in:
"Colour-Music as an Empire Idea", Sydney Morning Herald, 11 November 1912, p 3
http://nla.gov.au/nla.news-article15374294
In Hector's 1912 patents (AU1912003713 and GB191229615A), each key of an instrument became a wireless telegraphic key. Its spark was tuned to a remote coherer or resonator. Stringed instruments were similarly connected to the lighting circuit, *"adapted to vibrate synchronously"*. Invoking sound rather than radio waves, Hector's British patent cited an earlier patent for controlling submarines, likewise with sound. One day, he mused in the press, bulbs could change colour through the direct action of the waves of sound.
Later patents made no further mention of wireless broadcast. But his last patent, AU1937004075 of 1937, did mention an electronic organ, the Hammond, invented in 1935.

2. SOUND

Hector's diagram refers to experiments made by John Tyndall after 1880, whereby light evoked sound from a gas. Tyndall presented the results In his Bakerian lecture of 1881 before the Royal Society:
"Action of Free Molecules on Radient Heat, and its Conversion thereby into Sound",
Philosophical Transactions of the Royal Society of London, Volume 173, 1882, pp 291-354
https://royalsocietypublishing.org/doi/pdf/10.1098/rstl.1882.0007
A summary was published as "Sound and Radiant Heat",
Popular Science Monthly, Vol 20, March 1882
https://en.wikisource.org/wiki/Popular_Science_Monthly/Volume_20/March_1882/Sound_and_Radiant_Heat

Tyndall had seen experiments by Alexander Graham Bell in 1880, where different solids gave off musical sounds when hit by a light beam, which shone intermittently through perforations in a rotating disk. Tyndall tried something similar on gases and vapours, finding chloride of methyl gave off the loudest sound of the gases. Water vapour in air, too, gave a note that seemed as loud as the peal of an organ. He concluded the effect came from the rhythmic gain and loss of heat from the light ray. The pitch of the musical note was proportional to the rapidity of light pulses, governed by the speed of the rotating disk.

Hector found evidence in this experiment for a connection between sound, heat and light, and mentioned it in a 1922 essay. Tyndall himself, fond of an analogy, made many remarks to that effect in his more general works. Hector duly paid homage in a subsequent essay:
"Colour Music. Producing the Octave II"
Sydney Morning Herald, 25 February 1922, p 7
https://trove.nla.gov.au/newspaper/article/15979791
"…Tyndall, that incomparable physicist, long years ago, expressed the view that "every phase and experiment of sound has its analogue in light, and every phase and experiment of light has its analogue in sound"."

For the next 50 years, the experiments of Tyndall and others became a mere curiosity. Since then, the science of photoacoustic spectroscopy has arisen. A gas sample in a resonant container is radiated by distinct wavelengths. Absorption results in a heating effect and pressure pulses of sound are given off. These are amplified and measured to analyze trace gases, monitor greenhouse gases and so on. Methyl chloride (CH_3Cl), predominantly from natural sources, apparently provides the dominant input of halocarbons to the atmosphere.

MARCONI'S MAGNETIC DETECTOR (see page 4, below)

3. WIRELESS TELEGRAPHY

Since the 1830s, telegraphy had relied on electric currents passed along wires to send coded messages. The telephone, developed from 1876, relied on wires as well, and was able to convey the sounds of speech. Wireless telegraphy, however, relied on radio waves instead of wires. In 1901, Guglielmo Marconi was able to transmit a message by radio waves across the Atlantic. The following year he patented his magnetic detector for receiving signals.
The magnetic detector was commonly used on board ships up to the end of the First World War. Called a 'Maggie', the device was designed to receive Morse Code sent by a spark gap transmitter (indicated at the far right). The transmitter sent pulses of radio waves repeated at an audio rate, around several hundred per second. Each pulse of radio waves produced a pulse of current in the earphone, so the signal sounded like a musical tone or buzz in the earphone.

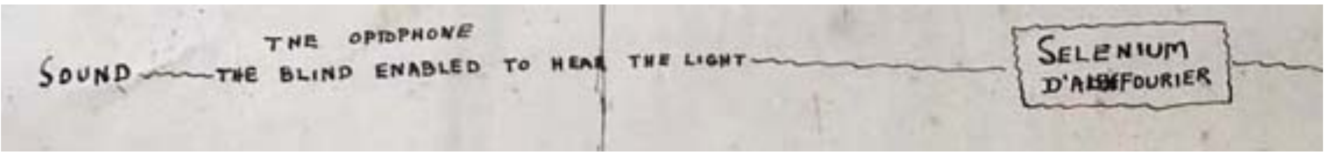
Hector described Marconi's magnetic detector in a paragraph on "Sound and Electricity: "Colour Music. Genesis of a Discovery I", Sydney Morning Herald, 18 February 1922, p 7
https://trove.nla.gov.au/newspaper/article/15967569
"…in wireless telegraphy the principle of Marconi's magnetic detector Is based on its ability to pick up the electrical waves, reduce their frequency by means of magnets and a clockwork arrangement, and by a microphone, having a very high résistance, to reduce the electrical oscillations to sound phenomena. Consequently, the operator having a suitable telephone arrangement in his ear, can hear the messages from various sources, and recognise the particular source by the particular note emitted."

Hector planned to broadcast colour music wirelessly.
"By this means a series of wave lengths could be flashed Into Space, and simultaneously a series of individual organs In different centres would burst Into music, and Into coloured harmonies of light", as reported in:
"Colour-Music as an Empire Idea", Sydney Morning Herald, 11 November 1912, p 3
http://nla.gov.au/nla.news-article15374294

In his 1912 patents (AU1912003713 and GB191229615A), Hector further described worldwide concerts using multiple colour-music instruments. A performer in a central location activated others remotely by sending radio signals. Each key of an instrument became a wireless telegraph key. Its spark was tuned to a remote coherer or resonator. [Marconi's magnetic detector had replaced coherers, which were older less sensitive devices.] Stringed instruments were similarly connected to the lighting circuit, *"adapted to vibrate synchronously"*, invoking sound as the link rather than radio waves. Hector's British patent cited an earlier patent for controlling submarines, likewise with sound. One day, he mused in the press, bulbs could change colour through the direct action of the waves of sound. (Perhaps this is why Hector linked 'light' to Marconi's detector, on the far right of his drawing.) Later patents made no further mention of wireless broadcast.

Marconi's magnetic detector itself was rendered obsolete in the 1920s by valves based on Lee De Forest's Audion (page 2, above). By then, sound transmission by radio waves had begun with amplitude modulation (AM) radio.

4. THE OPTOPHONE



The element selenium was found to transmit an electric current when light fell on it. Alexander Graham Bell and his assistant Charles Tainter took advantage of the property in 1879, to create the Photophone (or Radiophone). Light was reflected from a very thin mirror placed over the mouth of a speaking trumpet. As the mirror was distorted by sound, sunlight was altered and beamed to a distant selenium cell. Theirs was the first wireless telephone system and Bell considered it “the greatest invention ever made, greater than the telephone”.

In 1912, Edmund Fournier d’Albe invented the optophone, a machine to enable blind people to read. Dots of light shone on a page of text were reflected onto selenium cells. The current induced triggered a corresponding set of musical tones in a telephone receiver, the notes of a diatonic scale. When light intercepted specific black shapes of printed letters, notes sounded.
“On a Type-Reading Optophone”, E E Fournier d’Albe, 1914
https://royalsocietypublishing.org/doi/pdf/10.1098/rspa.1914.0061
The Optophone was popularized by Mary Jameson, a blind student who used it to achieve reading speeds of 60 words per minute. Though the machine was somewhat cumbersome and it could not compete with Braille cost-wise, it had advantages. Any typewritten text could be read, as could paper currency. An experimental model was made that used vibrations rather than musical notes; like Braille, it presumed the blind could read by touch as much as by coded sound.
"The Optophone: Its Beginning and Development ", Mary Jameson
https://www.rehab.research.va.gov/jour/66/3/1/25.pdf

Dada artists were intrigued by the Optophone. Francis Picabia would call two of his paintings Optophone I and II, in 1921-2. Raoul Hausmann wrote optophonetic poetry of non-linguistic noise; he devised and eventually patented his own kind of optophone, but never built it.
In World War II, optophones were used in attempts to rehabilitate blind soldiers. Some researchers attempted to extend its capacities, developing devices such as light pens. It may even be said the Optophone anticipated OCR and text-to-speech computer technologies.

D’Albe acknowledged the Photophone, and other like inventions (including Duddell’s Singing Arc, page 7, below), in his book on selenium. In Chapter Viii he indicated his Optophone was capable of playing music when activated by light:
"Needless to say, any succession or combination of musical notes can be picked out by properly arranged transparencies, and I have succeeded in transcribing a number of musical compositions in this manner, which are, of course, only audible in the telephone. These notes, in the absence of all other sounding mechanism, are particularly pure and free from overtones. Indeed, a 'musical optophone' worked by this intermittent light, has been arranged by means of a simple keyboard, and some very pleasant effects may thus be obtained."
“The Moon-Element: An Introduction to the Wonders of Selenium”, E E Fournier d’Albe, Fisher Unwin, London, 1922
https://archive.org/details/moonelementintro0000eefo

Selenium sensors were also used in the Light Beam Piano of 1926, activated by light passing through perforations in a rotating metal cover. It was played from a keyboard and its inventor, Mr Matthews, hoped it would replace the pipe organ.
In 1938, the Super Kodak Six-20 pack, the first camera to feature automatic exposure, was equipped with a selenium light meter.

5. A Musical Note

Hector’s diagram is described in a paragraph on “Sound and Electricity”:
“Sir Oliver Lodge has conducted several experiments along this line of research, and was able to so reduce the frequency or the vibrations of an electric spark to 400 vibrations per second, and these were found to produce a musical note.”
“Colour Music. Genesis of a Discovery I”, Sydney Morning Herald, 18 February 1922, p 7
https://trove.nla.gov.au/newspaper/article/15967569

Lodge summarized his experiments in converting electricity to sound:
***“I**t happens that I have myself succeeded in getting electric oscillations so slow as to be audible,—the lowest I had got in 1889 were 125 per second, and for some way above this the sparks emit a musical note; but no one has yet succeeded in directly making electric oscillations which are visible,—though indirectly every one does it when they light a candle.”*
He emphasized similarities between light and other electro-magnetic vibrations:
"With these Hertzian waves all manner of optical experiments can be performed. They can be reflected by plain sheets of metal, concentrated by parabolic reflectors, refracted by prisms, and concentrated by lenses.”
"The Ether Of Space", Sir Oliver Lodge, Harper & Brothers, London, 1909, pp 9-10
https://www.gutenberg.org/files/40911/40911-h/40911-h.htm

It is interesting to note that Hector gives a note of 400 Hz, a little sharp of the G above middle C, while Lodge’s 125 Hz is a little flat of the octave below middle C. I could not find 400 Hz in Lodge’s writings, though an earlier work gives a closer figure and a detailed description:

“…the optical and audible demonstration of the oscillations occurring in the Leyden jar spark…And first I will do it audibly. To this end the oscillations must be brought down from their extra-ordinary frequency of a million or hundred thousand a second to a rate within the limits of human audition…Notwithstanding the great capacity, the rate of vibration is still far above the limit of audibility, and nothing but the customary crack is heard. I next add inertia to the circuit by including a great coil of wire, and at once the spark changes character, becoming a very shrill but an unmistakable whistle, of a quality approximating to the cry of a bat. Add another coil, and down comes the pace once more, to something like 5000 per second, or about the highest note of a piano. Again and again I load the circuit with magnetizability, and at last the spark has only 500 vibrations a second, giving the octave, or perhaps the double octave, above the middle C. One sees clearly why one gets a musical note: the noise of the spark is due to a sudden heating of the air…”
“Modern Views of Electricity”, Sir Oliver Lodge, Richard Clay & Sons, London, 1889
https://archive.org/details/modernviewsofele00lodguoft

Lodge’s 500 Hz is a little sharp of the B above middle C. (It is odd that he might allow it to be an octave higher, at the double octave of 1000 Hz.) His note is about a major third higher than Hector’s 400 Hz. The sound is caused by heat from the spark, according to Lodge. (Likewise, Tyndall attributed sound to the heating effect of light alone, page 3 above.)
To decrease the frequency of the spark, Lodge added the coils of wire mentioned, increasing resistance in his circuit. To analyze the spark optically, Lodge separated it into component sparks with rotating mirrors.

6. THE WIRELESS PIANO

In 1913, Prince Albert I of Monaco sailed the Atlantic on his yacht Hirondelle. On board was Louis Tenayre, an artist who depicted the changing colors of phosphorescent fish dredged up from the deep. The radio operator, Pierre Boutteville, had charge of a wireless system invented by Baron von Lepel, which made musical notes. By adjusting the frequency of a spark, popular tunes and anthems were broadcast to all ships within range. The Marconi Wireless Telegraph Station in Nova Scotia was treated to four musical selections, including the Merry Widow Waltz, before the Prince sailed triumphantly into New York harbour.

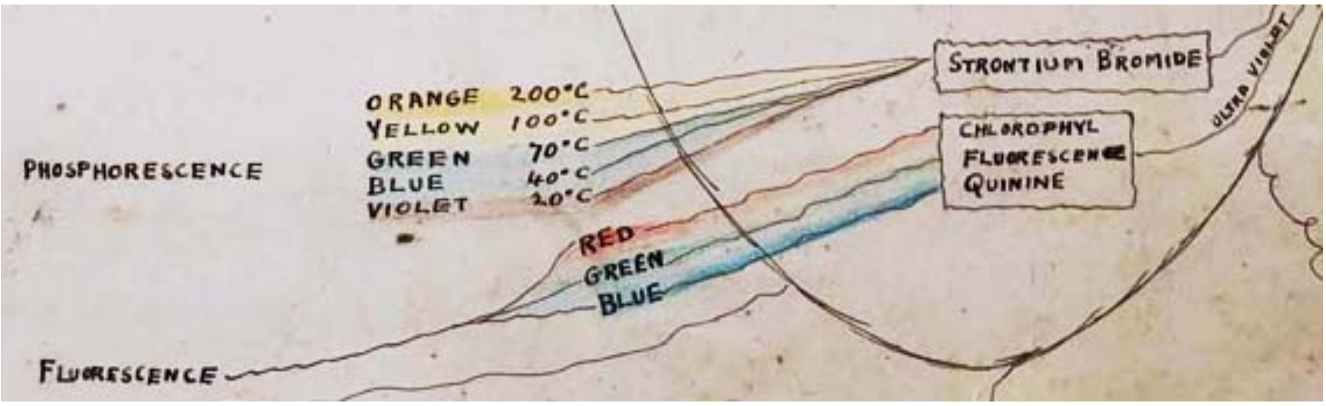
Hector already knew how an electric spark produced musical notes, from the writings of Oliver Lodge (see page 6, above). He read news of the wireless concert broadcast from the Hirondelle, soon after its arrival in New York:
"When on my trip to the old country in the steamer Orvieto, some years ago, I was informed by the wireless operator that someone was experimenting with an instrument which enabled music to be transmitted by means of wireless, and he described vividly his first experiences of its effect. Later, in the magazine "Modern Electronics," for November, 1913, appeared a description of a wireless piano, which had been constructed on the Prince of Monaco's yacht Hirondelle. The principle of this wireless piano is that, by varying the electrical impulses by means of resistances, it so varies the sounds received by operators within radius that wireless music can be conveyed from one centre to another, and all ships or stations within radius can hear the music simultaneously."
"Colour Music. Genesis of a Discovery I", Sydney Morning Herald, 18 February 1922, p 7
https://trove.nla.gov.au/newspaper/article/15967569

7. THE SINGING ARC

William Duddell made audible notes with his 'Singing Arc', by varying the voltage supplied to arc lamps. Streetlights connected to a keyboard were made to 'sing', their light fluctuating with the tune in a sound and light show. In 1903, Valdemar Poulsen added an antenna to the singing arc, converting it to radio frequencies. Sound could be transmitted wirelessly, and his device helped make long-wave radio broadcasting possible by 1920.

Hector briefly mentioned Poulsen's invention as a way of converting electricity to sound, in the first of three articles he wrote for a newspaper in 1922:
"*"In wireless telephony the singing arc of Poulsen Is practically based on the same principle of so collecting and modifying the transmission of electrical impulses that these impulses can be detected as sound."*
Colour Music. Genesis of a Discovery I", Sydney Morning Herald, 18 February 1922, p 7
https://trove.nla.gov.au/newspaper/article/15967569

8. PHOSPHORESCENCE & FLUORESCENCE

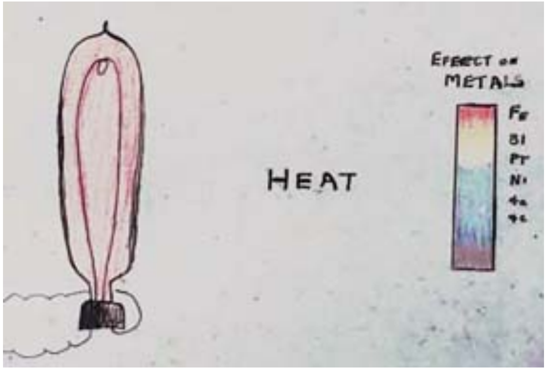


The colours and temperatures of phosphorescence listed appear to be taken directly from a well-known source:
“The colour also depends on the temperature during exposure to light. Thus A. E. Becquerel found that the light given by a specimen of strontium sulphide changed from violet to blue, green, yellow and orange. as the temperature during the corresponding previous insolation was 20°, 40°, 70°, 100° or 200° C.”
Encyclopaedia Britannia, 1911 edition
https://en.wikisource.org/wiki/1911_Encyclopædia_Britannica/Phosphorescence
(Becquerel was also the first to create a photovoltaic cell, at the age of 19.)

Hector appears to have mistaken strontium sulphide for strontium bromide in his diagram. (Alexandre-)Edmond Becquerel published the original results in the two-volume text, “Light, its Causes and Effects”, with colour plates to illustrate changes in phosphorescence when various substances are heated. (Phosphorescent colours of sulphides of strontium, barium and calcium were shown in Figure 32, Volume I, but none of their bromides.) Each substance was exposed to sunlight (insolation) while at the temperature specified, and continued to glow in the dark with the colour shown.
Becquerel examined Newton’s musical division of the spectrum (though he seems to employ a C scale rather than Newton’s scale starting on D). He compared it to his own scale of main colours, constructed with M-E Chevreul. Starting with violet as low pitch, followed by blue, green, yellow, red and extreme red, the notes would be C, E, F, G, A# and C”. “We cannot attach much importance to comparisons of this kind”, he concluded.
In his second volume, Becquerel looked at the work of Helmholtz on complementary colours. He examined their wavelength differences, finding them unequal: red and greenish-blue were a fourth apart (4:3), while yellow gold and blue were separated by a minor third (6:5).
"La lumière, ses causes et ses effets", Librarie de Firmin Didot Frères, Fils et Cie, 1867/1868
https://ia800808.us.archive.org/16/items/lalumieresescaus00becq

Fluorescence differs from phosphorescence in that the glowing colour disappears as soon as the light stimulus is removed. Typically, the colour of fluorescence is of lower frequency than the light shining on a substance. Hector includes pure violet on the right of his fluorescent substances: it might indicate the light stimulus of high frequency, which often includes an amount of ultraviolet light. Ultraviolet (black light) is normally invisible, making the intense fluorescence it provokes all the more dramatic.
In 1822, E D Clarke noted a green light transmitted by fluor spar, after which fluorescence was named. David Brewster in 1833 noticed red fluorescence from chlorophyll, the most widely distributed fluorescent molecule. John Herschel saw that quinine glowed with blue fluorescence, in 1845. Hector possibly intended to indicate these three early examples of red, green and blue fluorescences, in his drawing.

A. HEAT



To the right of the diagram, a vertical spectrum is labelled 'Effect on Metals'. Beside it are enigmatic symbols –

FE, BI, PT, NI, 4C, 4C

They are partly illegible: some suggest names of elements –

Fe = iron = red
Bi = bismuth = orange
Ni = nickel = green

The colours are not usually associated with these metals e.g. in flame tests.

Hector made some remarks about the relation of heat to the colour of metals, in the second of three articles he wrote for a newspaper in 1922:
"Colour Music. Producing the Octave"
Sydney Morning Herald, 25 February 1922, p 7
https://trove.nla.gov.au/newspaper/article/15979791
Discussing Colour Sequences, Hector noted the recurrence of rainbow effects, comprising red, orange, yellow, green, blue, indigo and violet. These particular colours (ROYGBIV for short) originated in Isaac Newton's "Opticks" of 1704, to describe the prismatic spectrum. The pattern occurred when heating steel or platinum, and from radium emanations, as well as in natural phenomena.

Hector experimented on steel himself, by heating the end of a file. Four successive rainbow effects were observed, each of ROYGBIV colours. The colour waves increased in intensity, he said, with each wave of heat.
He further described experiments on platinum by Draper, summarised in Tyndall's "Physics":
"As the heat is applied, It goes through the gamut of red to vlolet, and in inverse sequence as the metal cools."

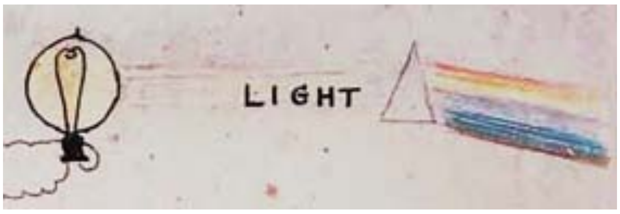
John Tyndall outlined the prismatic analysis of Dr Draper in his Rede lecture on "Radiation", given at Cambridge University in 1865. Draper passed an electric current through a platinum wire. The wire glowed a feeble red at first, passing to dazzling white as the current increased. The gamut of colours Hector described was only visible when the wire was viewed through a prism. Tyndall also named the revealed colours ROYGBIV, which accumulated successively to produce the final whiteness. He did not describe the colours disappearing in inverse sequence on cooling. (Tyndall went on to describe other experiments, of platinised platinum converting infra-red rays to visible white, which was also separable by a prism into ROYGBIV colours.)

Tyndall ended his lecture with a musical analogy:
"If you open a piano and sing into it, a certain string will respond. Change the pitch of your voice; the first string ceases to vibrate, but another replies. Change again the pitch; the first two strings are silent, while another responds. Thus is sentient man acted upon by Nature, the optic, the auditory, and other nerves of the human body being so many strings differently tuned, and responsive to different forms of the universal power."
A transcription of the lecture on "Radiation" is given in Chapter II of:
John Tyndall, "Fragments of Science," vol I, 1879 (6th ed), pp 28-73
https://ia801606.us.archive.org/8/items/in.ernet.dli.2015.219855/2015.219855.Fragments-Of.pdf

Hector had earlier expressed an interest in reversible colour changes. The press reported his observations, following a lecture delivered by the inventor at his home in Greenwich, Sydney, on June 13, 1912.
“Music and Colour”,
Sydney Morning Herald, 14 June 1912, p 8.
https://trove.nla.gov.au/newspaper/page/1292301
“He traced the relationship between radium and its emanations, and showed that the emanations when cooled first became iridescent, then blue, then yellow, and finally red under extreme cold; and when warmed these colours reappeared in inverse ratio. From this he endeavoured to show that practically all things obeyed the same colour scheme, which led him to the theory of colour harmonics and colour music.”
The paper repeated the observation in a later article,
“Colour-Music as an Empire Idea.”
Sydney Morning Herald, 11 November 1912, p 3
http://nla.gov.au/nla.news-article15374294
The following year, a magazine article revealed Hector’s source was "Radio-Chemistry", by A T Cameron:
"Colour Music"
"The Lone Hand", July 1, 1913, pp 240-43
https://www.google.com/books/edition/_/UOYtAQAAIAAJ?kptab=overview
Hector himself would explain the phenomena in his 1922 essay, mentioned above:
“When the emanation is collected and cooled, it first appears as a phosphorescent solid, and, as the temperature drops, the phosphorescence gives place to steel blue, then yellow, then cherry red. This sequence of colour appears, inversely, as the emanation Is heated.”

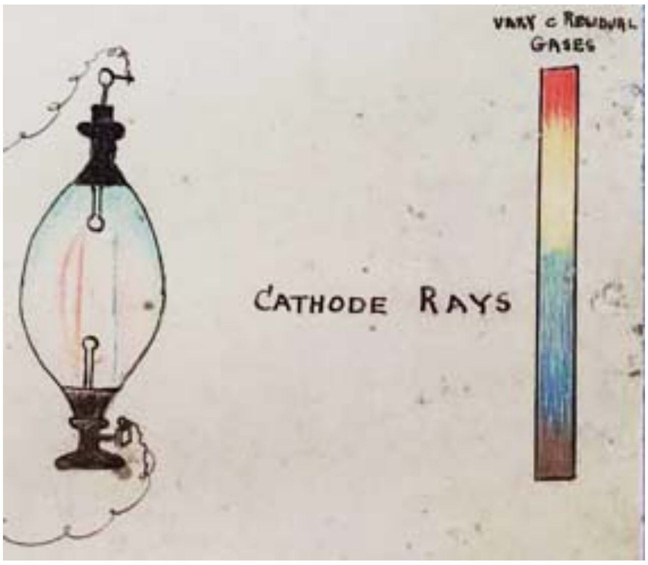
‘Radium emanation’ was a radioactive gas discovered in 1899. Its name was changed to niton in 1910, but the old name was commonly used. It was not until 1923 that the element was given its present name radon [Rn]. Hector used this modern name when he included it at number 86, on drawing of the periodic table from around 1925-30. Its phosphorescence at low temperatures was described by Hector’s source, as follows:
"The niton condensed to a colourless liquid, and when the temperature was sufficiently low, to an opaque solid. Liquid niton is transparent like water. It produces phosphorescence to an extraordinarily marked degree...The solid glows intensely, and has the appearance of a small steel-blue arc light, which changes successively with lowered temperature to yellow, and at liquid air temperature to a brilliant orange red. On warming, the colour change is inverted. Solid niton melts at -71 C, the liquid boils at -62 C."
"Radium and Radioactivity", A. T. Cameron
Society for Promoting Christian Knowledge, London, 1915, p 62
https://archive.org/stream/radiumradioactiv00camerich

B. LIGHT



A globe shines light through a prism, which breaks it into the colours ROYGBIV. Both the colour names and the experiment itself come from Isaac Newton’s work, published in “Opticks”, 1704.
Many people, including scientists, have used ROYGBIV as a shorthand description of colours in the spectrum or the rainbow. Sometimes it was abbreviated to ROYGBV, omitting the I for indigo. Hector used both sets in his early patents of 1912.
When defining a colour-music code precisely in his 1916 patents, Hector turned to Ogden Rood’s “Modern Chromatics”. There he found a completely different set of 12 colours. Still, he continued to use the simpler, commonly known ROYGBIV as a description in the press.

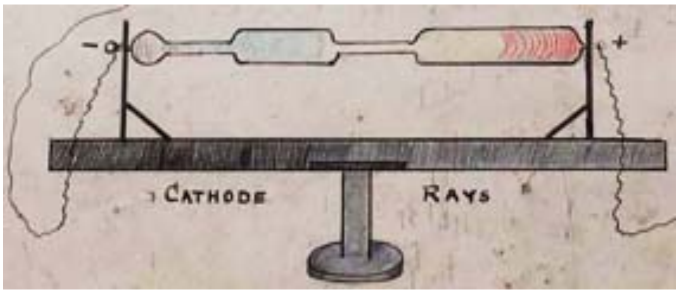
C. Cathode Rays



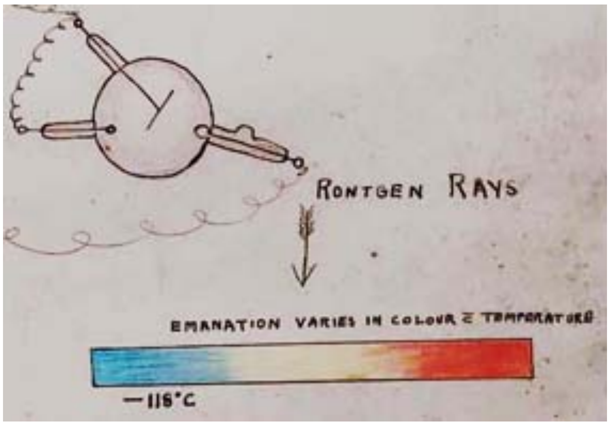
The bulb on the left seems to be a primitive kind of Crookes tube, supplied with a high voltage to the anode and cathode terminals within. It ionized a residual gas and positive ions collided with the cathode. A flow of electrons emerged – the cathode ray.
The vertical spectrum on the right suggests how a colour is emitted n the process, varying according to the residual gas within the tube. Neon gives red; mixed with metallic mercury it turns green; argon gives a blue light. An argon/mercury-vapour mix emits ultraviolet light, causing coloured phosphorescence of the glass or its coating, or from articles such as diamonds and rubies placed within the tube.

D. Cathode Rays

This kind of tube was known as a spectral or Plücker tube. The thin central section displayed a colour of light that depended on the type of gas inside the tube. They were used in classrooms, the colours studied with a spectroscope. Usually, a single colour was displayed, rather than the red and blue ends Hector has drawn.



E. Röntgen Rays



The drawing indicates that a bombardment of Röntgen rays (X-rays) can cause an emanation that varies in colour, when subject to a very low temperature.

The temperature of -118ºC, in the green-blue region of the spectrum, seems too high for common coolants. (Liquid nitrogen, for example, boils at -195.8ºC.) Hector's figure could be a transition temperature, passed through as a substance cools down or heats up. Otherwise, he might be quoting a specific experiment from an untraced source.
One such possibility is "Quantitative Roentgen Spectrum Analysis by Means of Cold Excitation of the Spectrum", by Glocker and Schreiber. In 1928, it was the most advanced text on the subject. For the next 20 years, progress was to stall, until the advanced science of X-ray fluorescence (XRF) emerged. Now instruments can count the photons emitted from a very cold substance when bombarded.

Neon lights were mentioned in Hector's last patent of 1937. A diagram showed 12 of them mounted over a piano, decreasing in size like a truncated pyramid. No colours were given. The international patents of Claude Neon had expired in 1932, allowing others to use them.

F. KEYBOARD

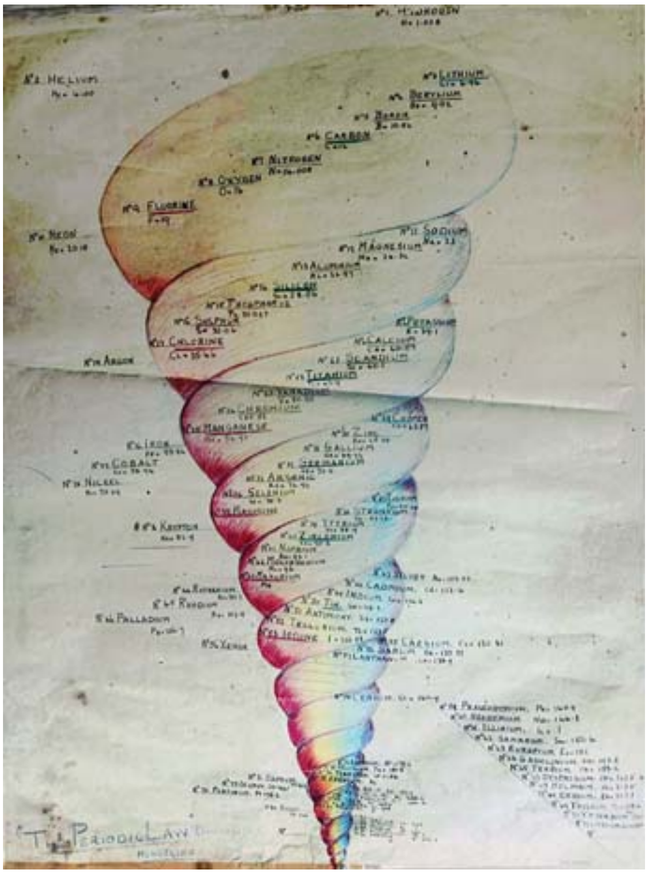
Hector has drawn an unusually large keyboard of 101 keys, from a low F on the left up to A on the right, encompassing 8 octaves and a major third. (A normal piano keyboard has 88 keys, from low A to a high C, covering 7 octaves and a minor third.) A single spectrum is stretched end to end: most often Hector gave it a single octave though it was sometimes expanded over 3, 4 or even 6 octaves in his patents. (see Hector-code.pdf)
The colours are similar to the Newtonian ROYGBIV, except there seem to be two greens, one with a yellowish cast, the other more blue. All are allowed about an octave each, with indigo (deep blue) expanded a few notes. This way, the full range is coloured.

From the earliest reports, Hector seems to have a fascination for the octave as an organizational unit. He could overlook the discrepancy between an octave of music and the spectrum - where frequencies do not double, end to end - by generalizing about vibrational phenomena. For this he sought support in the writings of Tyndall, Lockyer, Newland and other scientists, prominent in England when he was learning his trade.
"He found also, as did Lockyer, another investigator, that octave progression of colour and music had its correlation in the human body. Its range covered the following: — Warmth, touch, taste, smell, hearing, seeing, and thinking. It is not difficult to follow and reason out in oneself."
"Colour Music: Sydney Inventor's Achievement", The Sydney Mail, 5 June 1912, p 21
https://trove.nla.gov.au/newspaper/article/160341655/16769651

J Norman Lockyer was the British Astronomer Royal, known for his spectroscopic analysis of the sun. In "Studies in spectrum analysis" of 1878, he had plenty to say about hearing and seeing, but nothing about the other senses of touch, taste and smell. As for warmth, Lockyer relied on heat to melt and vaporize substances so he could study the colours they gave off. He generalized that heat worked on a molecular level while electricity provoked its own reactions from atoms. Lockyer thought all of these studies added to the sum of human knowledge, but it appears he was little interested in any *"octave progression of colour and music"*, let alone *"its correlation in the human body"*.

In his first chapter, Lockyer dealt with the wave motion, starting with waves in water then sound waves in air, finally likening them to light waves in the ether. Like many scientists in the latter half of the 19th century, he believed ether essential to the electromagnetic field, an exciting new realm where light operated. It mysteries might be uncovered by analogy to sound, and Lockyer drew many parallels between the physics of light and sound, between the eye and the ear. He came closest to Hector when discussing the prism, comparing any single colour to one note on a piano, and white light to all the notes played at once. Lockyer lists the prismatic colours as red, orange, yellow, green, blue, violet and indigo. (Unfortunately, he reverses the last two colours of ROYGBIV, which I presume is a mistake.) The ends of the spectrum are equated to notes of different pitch though no interval, either octave or major 6th, is specified:
""Now, the difference between the blue light at one end of the beautifully coloured band and the red at the other, is nothing more nor less than a difference almost identical with the difference between a high note and a low note upon the piano."
"Studies in spectrum analysis", J N Lockyer, Kegan Paul, Trench, & Co, London, 1886
https://archive.org/details/in.ernet.dli.2015.102573

THE PERIODIC LAW (MENDELIEF)



A B Hector, THE PERIODIC LAW, c1925-30
[Mitchell Library, State Library of NSW]

Hector drew the periodic table as it was known at the time, spiralling down a cone from hydrogen at the top to uranium at the bottom. It helps date this and other drawings to the period 1925-30, immediately after Hector retired as managing director of the drug firm, Burroughs Wellcome.

Hector stressed repeatedly that the periodic law supported his theory of colour music, and the octaves that united them:
"That law of octaves was a new thing to him, but after he had got a certain way with it, and began to look around for the observations of others, he found that Newland forty years ago had constructed a. spiral to express the law of octaves. Mendelliеf's "Periodic Law in Chemistry" supplied him with further inspiration, and then came Mr. Hector's major discovery, which coincided with that of Professor Rimington."
"Colour Music: Sydney Inventor's Achievement", The Sydney Mail, 5 June 1912, p 21
https://trove.nla.gov.au/newspaper/article/160341655/16769651

Hector read of John Newlands' law of octaves in George Newth's "Inorganic Chemistry":
"Newlands (1864) was the first to point out, that if the elements are tabulated in the order of increasing atomic weights, the properties belonging to each of the first seven elements reappeared in the second seven, and he applied to this relation the name of the law of octaves."
"Colour Music", "The Lone Hand", July 1, 1913, pp 240-43
inside https://www.google.com/books/edition/_/UOYtAQAAIAAJ?kptab=overview
Newth, in his "Textbook of Inorganic Chemistry" of 1894, went on:
"A more elaborated and systematic interpretation of Newlands' law of octaves was afterwards developed by Mendelejeff (1869), and which is now generally known as Mendelejeff's periodic law."
In the 11th edition of his book, in 1905, Newth made interesting editions to his text:
*"At the present time, owing to the recent discovery of the argon family of elements, it is not until eight elements have been traversed that the properties of the first reappear; the term "octaves" is therefore no longer strictly applicable.**
**Unless, indeed, we stretch the musical simile somewhat and look upon these five inert gases as "accidentals"."*
"Textbook of Inorganic Chemistry", G S Newth, Longmans Green & Co, London 11th ed, 1905
https://archive.org/details/atextbookinorga03newtgoog

Hector may not have read Newth's later book, but Newland's octave theory of elements had quickly been surpassed. Nor was it readily accepted: at a presentation to the London Chemical Society in 1866, he was mockingly asked if an alphabetical order might be even better. (Newth's ironic footnote about 'accidentals' indicates the idea was a curio by 1910.)

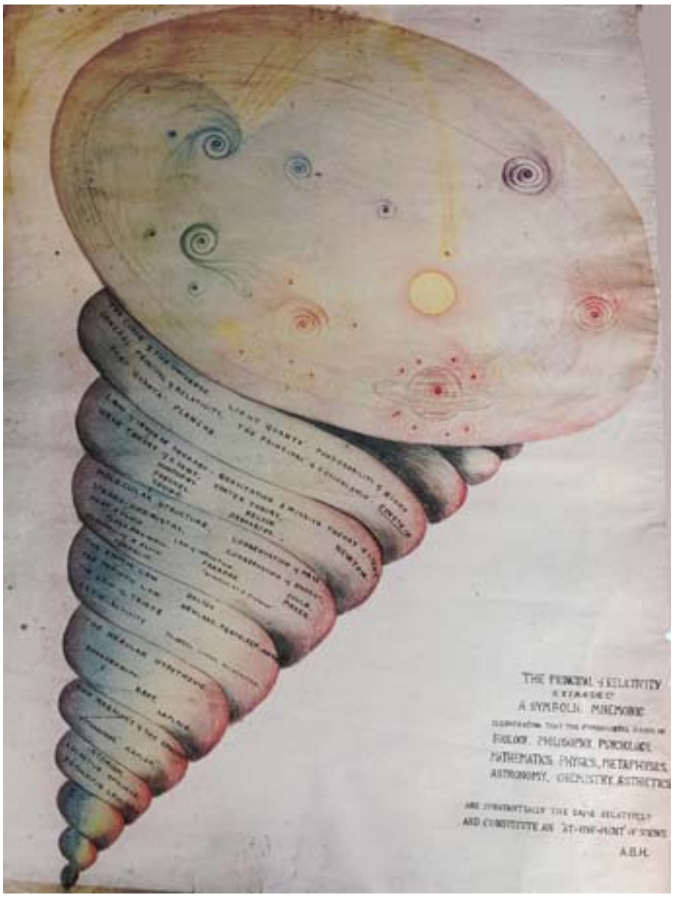
Hector named the elements correctly for his time (1925 on). Some were later renamed and others yet to be discovered. All are very rare and/or highly unstable.
No 43, **Technetium** - rare, radioactive, unstable. Hector called it Masurium, a false identification made in 1925. No 43 was correctly identified and renamed in 1937.
No 61, **Promethium** - . very rare, radioactive, unstable. It was named Illinium in 1925, called such by Hector, but its "discovery" was soon proved to be false. No 61 was produced and characterized in 1945, announced in 1947
No 72, **Hafnium** - last stable element to be discovered in 1923. Hector included it
No 75, **Rhenium** - very rare, 2nd-last stable element discovered in 1925. Hector included it.
No 85, **Astatine** - unstable, rarest natural element. Hector leaves a blank. Discovered 1940.
No 86, **Radon** – (see page 10, above) called "radium emanation" (which Hector used in interviews), then Niton in 1910. It was renamed radon after 1923, which Hector uses here.
No 87, Francium - second rarest naturally occurring element, most unstable, extremely radioactive. Discovered in 1939. Hector leaves a blank.

THE PRINCIPAL OF RELATIVITY

A disc showing the solar system sits atop a cornet shape, similar to his Periodic Law diagram (page 13, above), Winding round the cornet, Hector has inscribed a history of science, from ancient Greece at the bottom to the age of quantum theory at the top. Its title reads:

The Principal of Relativity: Expanded
A Symbolic Mnemonic
Biology – Philosophy – Psychology,
Mathematics – Physics – Metaphysics,
Astronomy – Chemistry – Aesthetics,
are substantially the same relatively and
constitute an "At–One–Ment" of Science.

Mentioning Planck and Einstein, and their related discoveries, shows Hector was aware of contemporary physics. The inclusion of light "quanta" may indicate he had not yet heard the equivalent term 'photon', coined in 1926. It may also have posed problem for his colour music, based on light's behavior as waves rather than photons. But the "At–One–Ment" of Science may have encompassed all, and smoothed the difference for him.



A B Hector, THE PRINCIPAL OF RELATIVITY, Mitchell Library, State Library of NSW.

The cornet shape first appeared as a stage prop, illustrated in "The Lone Hand" in 1913. Inverted, like a Christmas tree, coloured light displays wound up its spiral in decreasing sizes. Spiral motifs, described as logarithmic, were used repeatedly for lighting displays in many of Hector's patents. The planets drawn above form a spiral, too. A comet (with yellow tail) is nearest the sun: counting the planets anticlockwise, ringed Saturn lands in the right place and Neptune is last. The drawing would thus predate the discovery of Pluto in February 1930. Another spiral would be the "spinning electron", briefly mentioned in Hector's 1926 patents. By 1937, he was more attracted to newer technology, planning colour films of performances.