Applications of the Thermionic Valve.[1]

By J. Joseph.

The control of energy at distances of thousands of miles without any other medium than the æther has been made possible by the evolution of the thermionic valve. This remarkable invention can be described briefly as a highly exhausted glass bulb, in which is mounted a tungsten or tantalum filament heated by a battery giving about 6 volts. Electrons are emitted by the heated filament. The filament is surrounded by a grid or gauze cylinder, which is insulated and kept at the negative potential of the filament, while a plate of metal mounted inside the bulb is kept at a high potential of from fifty to several hundred volts by means of a battery or some other source of continuous current. The bulb is highly exhausted, and while the grid is kept at a normal negative potential, steady current passes from the filament to the plate or anode, but as soon as the grid is made slightly positive or negative, the current passing between the filament and anode by virtue of the electronic conductivity is increased or decreased. A valve can be used as a rectifier, as it can be made unilateral in conductivity by suitable adjustments of "grid potential." It can also be regarded as an inertialess relay, it being only necessary for the grid to be affected by the most minute change of potential for the valve to become more or less conductive, when it may be used indirectly to close a circuit and control magnetic or electrical operations.

One of the most important applications of the valve is the amplification of telephone currents in long-distance telephone trunk lines. Here, owing to the length of the cable and to the electrical constants involved, speech becomes greatly attenuated, and thermionic relays or repeaters are introduced about every thirty miles which amplify the speech to its original degree of loudness. In addition, cable of much smaller diameter and weight can be employed, as currents producing almost inaudible sounds can be amplified to any degree of strength. The introduction of these valve relays has effected a saving of thousands of pounds in many of our trunk telephone lines.

Another recent application of the valve is the magnification of the sound of the heart-beat. This is effected by means of a special transmitter, which rests by its own weight over the heart of the patient under examination. The heart creates vibrations in an air-chamber which reproduce exactly the complex action of the blood when passing through the valves of the heart. When connected to a thermionic valve amplifier and a special receiver attached to a large horn, the beat of the heart can be made audible to a number of people in a lecture-room.

The valve has also been used for the simultaneous reproduction of speech with the projection of a film on a screen, both picture and sound vibrations being photographed simultaneously on the same film, thereby ensuring perfect synchronisation. The vibrations of the voice are, by means of microphones, made to agitate a small mirror fitted on the camera adaptor, and a shaft of light passes from the mirror through a narrow slit. As the mirror vibrates, the band of light is reflected at constantly changing angles, and a wave form is produced which corresponds to the vocal sounds of the person speaking, as in the oscillograph. The wave form appears on the side of the film and is reconverted into sounds by means of a selenium cell, which, as is well known, possesses the peculiar property of resisting the passage of electricity in proportion to the intensity of light to which it is subjected. The variations in resistance caused by the passage of the film through the cinematograph are amplified by thermionic valves and made audible through a loud-speaking telephone. There are wide possibilities in this application of the valve.

An important feature of the valve is its great adaptability to the production of sounds of any frequency from one to many millions per second. A valve can be made to generate oscillations if the grid and anode are coupled to coils so as to form a transformer, the circuit of the coils being completed through a battery of 150 volts or more. By connecting a condenser across the anode coil, oscillations are set up, the frequency of which depends on the capacity of the condenser. If a third coil is coupled magnetically to the anode circuit, a note will be emitted corresponding to the frequency of the circuit, and by varying the capacity of the condenser, a wide range of frequencies can be generated for various testing purposes. The note emitted by the receiver is very clear and sharp, and the ease and rapidity with which the frequency can be changed renders the method particularly suitable for aural surgery, where frequencies covering a range of 200 to 3000 are often required. It is well known to aural specialists that certain people have what is known as a silent zone at particular frequencies. For instance, a patient's hearing might be normal for frequencies 200-500 and although he is deaf to frequencies 500-520. The aural appliances at present in use are not suitable for the rapid and accurate production of frequencies of any desired value. With a thermionic generator and a calibration chart, however, the frequency can be varied at will, and if a telephone head-receiver is worn by the patient and connected in series with a variable air condenser and the output or coupling coil, it can be determined readily what frequencies are inaudible to the patient. Further, by varying the capacity of the condenser the sound can be reduced gradually to inaudibility and, by calibration, a scale obtained which will give positions for normal hearing, imperfect hearing, and so on. By this means the effect of treatment can be determined to a very fine degree.

The human ear will not easily respond to frequencies greater than 3000 per second, although frequencies of 18,000 can be detected and instances have been known where 30,000 to 40,000 have also been heard. The frequencies used in wireless telegraphy are governed by the wave-length, and values of 500,000 per second, which correspond to a wave-length of 600 metres, are quite common. In spark telegraphy, the wave trains are

[1] Substance of a contribution to a discussion at the Institution of Electrical Engineers on March 6.

cut up into groups which are rendered audible to the wireless operator by means of a telephone receiver, which gives a click for every wave train, the signal being, of course, first rectified by the valve, so that a succession of musical sounds are heard in the telephone receiver corresponding to the Morse alphabet. The intermediate or high frequencies in each wave train are beyond human audibility, and are therefore not heard. The wave generated by the valve is, however, a continuous one, that is to say, every time the sending key is pressed a group of continuous waves are sent out at a frequency determined by the wave-length. To render them audible in the telephone at the receiving end, a local valve oscillator is used for generating frequencies slightly lower or higher than the received signal and, by heterodyning or superimposing one on the other, a frequency equal to the difference of the two notes is heard in the telephone receiver. This allows of exceedingly fine tuning, for the frequency of the local generator being under the control of the receiving operator, the difference in pitch is adjusted to 1000 cycles, the best value for human reception. It will therefore be seen that frequencies of as low as 1 can readily be detected, although, when the difference becomes very small, there is a tendency for one oscillator to pull the other into step.

Probably, the most interesting application of the thermionic valve is its use in radio-telephony. Here the valve is used to generate continuous waves in a suitable circuit and, by means of a microphone, the voice of the speaker is made to vary the amplitude of this wave at the different audible frequencies which are used in speech formation. These modulations are then conveyed to the aerial, and the telephone diaphragms at the receiving end are correspondingly stimulated and reproduce the speech exactly as transmitted. Numerous other uses have been found for the thermionic valve, among which may be mentioned direction finding, the navigation of aeroplanes in flight, its use as a rectifier for charging batteries, communication between moving trains, and the control of energy at great distances. In the latter direction mention may be made of communication by radio-telephony having been definitely established between England and Australia. Wherever a succession of signals can be received, they can always be amplified and made to operate selective electrical or mechanical relays for controlling power of any magnitude. The future holds a wonderful vision of vast operations at one end of the earth, being controlled by mankind at the other without any other medium than the æther.

Obituary.

PROF. PHILIPPE A. GUYE.

BY the death of Prof. Philippe Auguste Guye, on March 27, Switzerland loses one of the most eminent of her savants, and the world of science is the poorer by the passing away, in the full maturity of his intellectual powers, of an assiduous and successful cultivator of natural philosophy, distinguished alike for the range and profundity of his knowledge, the force of his genius, his originality, his ingenuity and remarkable experimental skill. Geneva has long been a home of science; some of her citizens are among the most honoured of its votaries, and Guye now assumes his due position on a roll already made illustrious by the names of Saussure, De La Rive, and Marignac.

Philippe A. Guye was born at Saint-Christophe (Vaud) on June 12, 1862. His earliest scientific studies were made at the University of Geneva, where he worked under Graebe, with whom he published papers on diphthalyl and on naphthalene hydrides—a modest enough theme for the 'prentice hand—mainly a repetition of Graebe's observations of ten years previously, which seemed to have been called in question by the subsequent work of Agrestini. After taking his doctorate he repaired to Paris, where he remained some years, working in the laboratory of Friedel. Here he appears to have come under the influence of ideas on spatial chemistry which science owes to Le Bel, and much of his work during the next few years was devoted to their development. In 1892 he was recalled to Geneva to occupy the chair of theoretical and applied chemistry in the university of that city, to which he remained attached for thirty years. During this period Guye, by his energy and personal influence, his organising power, and the catholicity of his scientific aims, made an indelible impression on the academic life and activities of the university. He surrounded himself with a body of earnest and enthusiastic workers, attracted from all parts of the world, to whom he gave freely from a wealth of ideas which ranged over every department of chemical and physical science. It is estimated that upwards of 600 communications emanated from the Geneva laboratory while under his direction, some 200 of which bore his own name alone, many others being joint contributions by himself and his pupils. His own work was characterised by a rigorous sense of accuracy, by caution and a recognition of possible sources of error, amounting almost to intuition, combined with a capacity for generalisation and a *flair* for fruitful hypothesis which seemed, at times, like divination.

Although Guye began his scientific life under the guidance of Graebe, and at a time when the theory of organic chemistry and its technical applications were developing with extraordinary rapidity and success, systematic organic chemistry of the type with which the name of his eminent teacher is associated had few attractions for him, and it is doubtful whether Graebe's teaching and example had any permanent influence on his career. At all events, on his election to the Geneva chair he embarked upon the long series of investigations on problems of physical chemistry on which his fame mainly rests. He was early attracted to the many issues to which the molecular theory of Van der Waals gave rise. He discovered a series of new relations between the physical constants of liquids and their molecular magnitudes, and he greatly