consequently raised to its highest state of oxidation, but this is not the case. At any given moment the action between metal and oxygen is necessarily confined to the thin layer of oxygen which is in immediate contact with the metal. This is very small in comparison with the metal exposed, and for this reason the lower oxides are chiefly formed in all cases of oxidation of metals by heating. Iron develops, not the beautiful red sesquioxide (peroxide), but the pitch-black magnetic oxide.

When copper is heated, the red cuprous oxide first appears, but at high temperatures some black cupric oxide is formed also. The colors of these compounds, however, do not matter in the first stage of the process, for the exceedingly thin coating affects the eye, not by its proper color, but through its character as a thin plate, giving rise, for example, to the familiar and beautiful tints of tempered steel. The tempering colors of copper and bronze, which are less often seen, are even more beautiful and brilliant, for the proper color of the metal shines through and blends with them.

When copper or bronze is heated for a longer time or to a higher temperature than is required for the production of tempering colors, the layer of oxide becomes thicker, reflects its proper color, and is called fire patina. In its manifold gradations it offers a beautiful and certainly the best and most natural means of softening and mellowing the offensive glitter of the bare metal.

Large bronze figures intended for open-air monuments cannot be coated with fire patina, because they cannot be placed in kilns and heated gradually to the requisite temperature. For them true patina, which may also be called weather patina, will ever remain the natural artistic finish.

In the production and estimation of fire patina, as in so many other branches of art, the civilized nations of eastern Asia, the Chinese, and especially the Japanese, have been our teachers. The Japanese first discovered that differences in the composition of bronze strongly influence the character and color of fire patina, and they have made admirable use of the discovery. By adding antimony to their bronzes they obtain black and dark brown tones, while the highly-esteemed warm red-brown shade is produced most easily on bronze which contains a little gold. The material of many small Japanese bronzes proves to contain gold, and a skillful European worker in bronze has assured me that he can secure certain effects for which his work is celebrated only by the aid of this costly ingredient.

With the consideration of fire patina we have reached the end of our subject. In fire patina we have an example of the possibility of obtaining, under conditions which increase the activity of the effective agents, results similar to those of age.

As it is the task of art to create inspired images of nature, so the processes of patination to which these images are subject from their birth are symbolical of the changes wrought by time in all created things. Even the stars that circle through space are, when "new," uncomfortable, shining, blazing spheres—very different from our beloved earth. They become fair and habitable only after they have been covered with rifts and cracks, with dust and debris, with oxides and hydrates and swarming parasites. Thus the earth and her gentle consort the moon have been made lovable—by patina!—Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from Prometheus.

A NOVEL THERMO-ELECTRIC BATTERY.

By EMILE GUARINI.

VERY many arrangements have been devised in recent years for rendering the use of thermo-electric sources of current practical. Since the discovery of the See-

beck and Peltier effects, endeavors have been made, but unfortunately without satisfactory results, to construct a generator of the kind under consideration, the consumption of which should not be excessive.

The great losses of heat, through radiation especially, and through conductivity, are, as we know, the causes that have intervened to prevent such apparatus, which run so regularly, are so easy of maintenance, and so clean in their operation, from getting beyond the laboratory.

Some very good types have nevertheless been constructed, although their operation is as yet costly, and their efficiency not very high. This, in the best generators, among which may be mentioned those of Noe, Rebizek, Clamond, Chaudron, and Gulcher, scarcely exceeds a few thousandths. There is, therefore, a great loss of energy, which is due, aside from losses by radiation, to the great quantity of heat that is carried along by the gases resulting from combustion.

Despite such acknowledged inadequate efficiency, thermo-electric batteries are still quite frequently employed, say in chemical laboratories, and for electro-metallurgic purposes, etc., by reason of their constancy,

When it is properly operated and treated, the thermomotor possesses all the stability that could be expected of a thermo-electric generator, and constitutes a very recommendable source of electricity for the special uses for which it is designed, viz., electro-metallurgy, thermo-chemistry, medical applications, telegraphy, telephony, signaling, and charging of small batteries, accumulators, etc.

A NEW SECRET SERVICE TELEPHONE.*

By the English Correspondent of SCIENTIFIC AMERICAN.

A NEW system of intercommunication telephone, the

SECRET SERVICE TELEPHONE. PLAN OF WIRING SYSTEM, SHOWING HOW COMPLETE SECRECY IS SECURED BETWEEN ANY TWO STATIONS.

their regularity, their cleanliness, and the small amount of attention they require.

As a general thing, very neat and, upon the whole, but slightly cumbersome thermo-electric batteries—particularly those heated with gas and kerosene—are extremely safe.

The generators heated with gas are the ones now most employed, those heated with kerosene and charcoal being scarcely any longer used except in cases where there is no supply of gas available.

It is for heating with gas that has likewise been constructed and recently put upon the market by a German firm a type called the "thermotor."

The arrangement of this battery is very interesting. The generator consists of four rows of elements disposed in pairs, on each side of two heating frames. The linear expansion of the latter is the principle upon which is based the regulation with which apparatus of this kind is provided. Under the influence of heat, the frame expands and, through the intermedium of a lever, acts upon the admission valve.

The thermotor is constructed for a mean pressure of about 40 mm. (1.57 inches). It is with this pressure of the gas that it gives its maximum production. When the pressure varies, the efficiency diminishes. The quantity of electricity produced decreases when the gas pressure diminishes, and increases when it rises.

A too great increase of the pressure would be followed by an excessive heating of the elements, prejudicial thereto, and it is for the purpose of preventing such heating that the regulating arrangement is provided, which it is well to previously adapt to the pressure of the piping by means of suitable screws and set screws.

With a discharge of 4 watts (small type) or of 8

most salient characteristic of which is that absolute secrecy and privacy are secured while conversation is being maintained between two persons, has been introduced by the General Electric Company of Great Britain. Several attempts have been made for the purpose of surmounting what has hitherto been considered one of the inherent defects of the telephone, i.e., interruption and tapping of the line while conversation is in progress. The majority of such experiments, however, have proved futile, owing to the resulting instruments being too complicated in design, and therefore impracticable.

In this latest device it is absolutely impossible for any tapping, interruption, overhearing, or leakage to take place. Two stations cannot be rung up simultaneously, even by accident, through careless placing of the switch, as in the majority of instruments. The instrument possesses several important novel developments of telephone work, and is somewhat a departure from the usual type. Moreover, it is perfectly simple in its design, with a minimum of working parts liable to derangement.

Arranged along the base of the instrument are a number of drop indicators, corresponding with the number of lines connected therewith, and immediately below these are the "jacks" or plug sockets. The connecting plug carrying a length of flexible cord is inserted into any "jack," according to the line it is desired to communicate with. When a call is made, the indicator corresponding with that particular line falls, denoting at once who it is that is calling. In the event, however, of the room being vacant at the time of the call, the indicator serves a very useful purpose, as it clearly denotes, when the person returns, who it is that has rung him up. Secrecy is insured by the provision of a complete metallic circuit to each pair of stations.

The method of operating the service is simple in the extreme. The operator can place himself in direct communication with his correspondent at any other station by the simple insertion of the plug into the desired "jack," and pressing a ringing key. At the other end of the line a distinct signal is given by the falling of the indicator shutter, which serves to point out the particular station that is ringing up, attention being attracted by the ringing of the bell. Should, however, the plug happen to be left in the "jack," a buzzer comes into operation and fulfills the same purpose.

The accompanying diagram indicates the principle of wiring a series of stations upon this system. In this particular instance a five-line installation is shown, in addition to the terminal board apart from the instrument itself, for the purposes of clearly demonstrating the method of connection.

Station No. 1 is shown in the normal position, No. 2 is in communication with No. 3, and No. 4 is in the act of ringing up No. 5. The operation is carried out as follows: No. 4 station desires to call up No. 5. The plug is inserted in the jack corresponding to that number, and the ringing key is depressed. This causes the shutter No. 4 to drop at station No. 5, completes the local-bell circuit, and announces the call. The dropping of the shutter at once indicates who it is that is calling, and the correspondent at No. 5 inserts his connecting plug in No. 4. Directly the "hand-coms" are removed from their cradles, the two persons are instantaneously placed in direct communication, and it is absolutely impossible for an operator at any other station to interrupt or overhear what is transpiring between the two conversationalists. Should, however, No. 1 call up No. 5 while the latter is talk-

* Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.

THE THERMOTOR.

beck and Peltier effects, endeavors have been made, but unfortunately without satisfactory results, to construct a generator of the kind under consideration, the consumption of which should not be excessive.

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watts (large type) the consumption rises to 100-110, 200-220 liters an hour (3.53-3.88 or 7-7.6 cu. ft.).

As in all apparatus of this kind, the pressure of the feed-gas has an important influence not only upon the consumption, but also upon the life of the apparatus. It is desirable, from all points of view, that the thermo-electric elements shall not be overheated, and that the admission shall be regulated once for all, afterward allowing the regulator to complete the regulation according to requirements.