United States Patent

[11] 3,580,637

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[21] Appl. No. **766,262**
[22] Filed **Oct. 9, 1968**
[45] Patented **May 25, 1971**
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[32] Priority **Oct. 21, 1967**
[33] **Japan**
[31] **42-67503**

[54] **METHOD OF DESTROYING FERROCONCRETE, ROCK OR THE LIKE**
5 Claims, 11 Drawing Figs.

[52] **U.S. Cl.** **299/14,** 219/213, 241/1
[51] **Int. Cl.** **H05b 1/00,** E21c 37/18
[50] **Field of Search** 175/16; 299/14; 219/213; 241/1; 125/1

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Attorney—Fidelman, Wolffe and Leitner

ABSTRACT: The method of destroying a ferroconcrete body formed of a concrete mass having metal reinforcement bars embedded therein, said method uses the reinforcement bars as electrical conductors and heats them by the application of electric current thereto to cause sufficient thermal expansion of the reinforcement bars to cause cracking of the concrete and to simultaneously lower the adhesion between the reinforcement bars and the concrete.

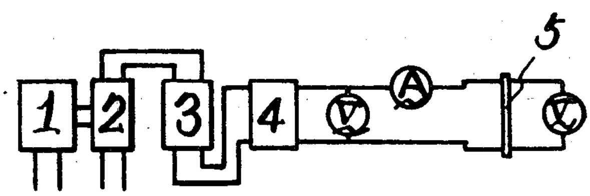


FIG. 1

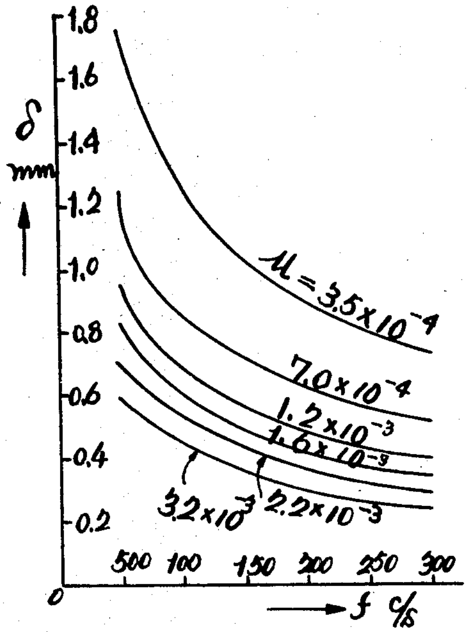


FIG. 2

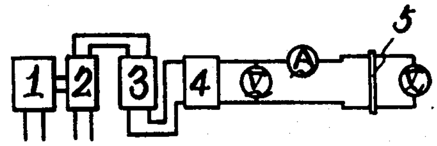


FIG. 3

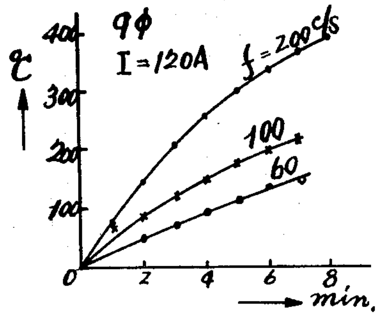


FIG. 4

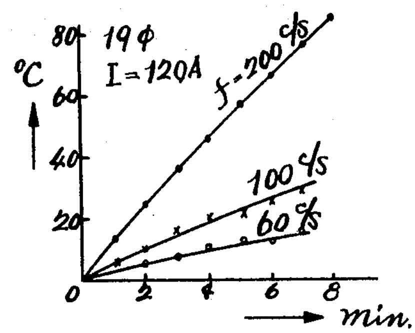


FIG. 6

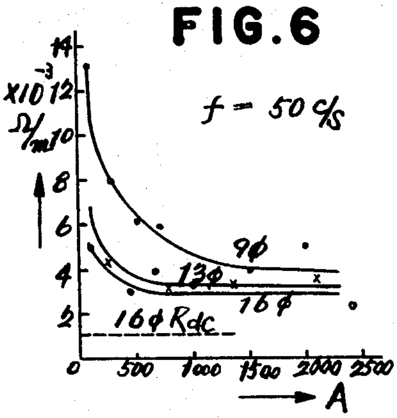


FIG. 5

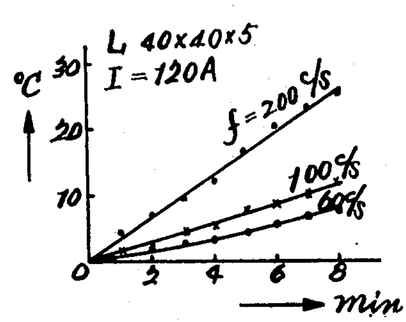


FIG. 7

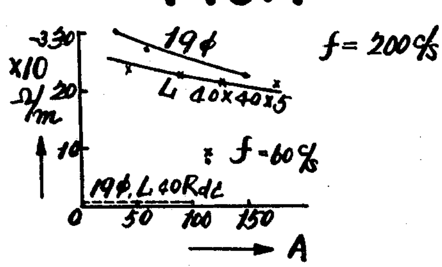


FIG. 8

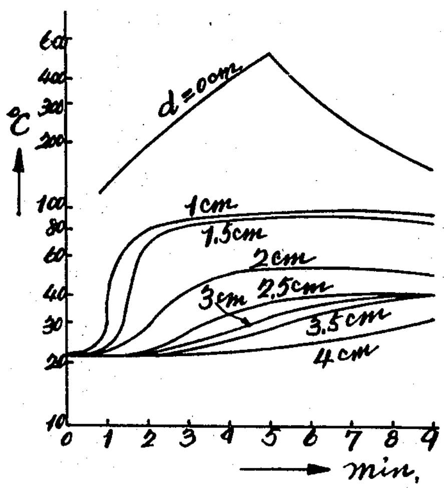


FIG. 9

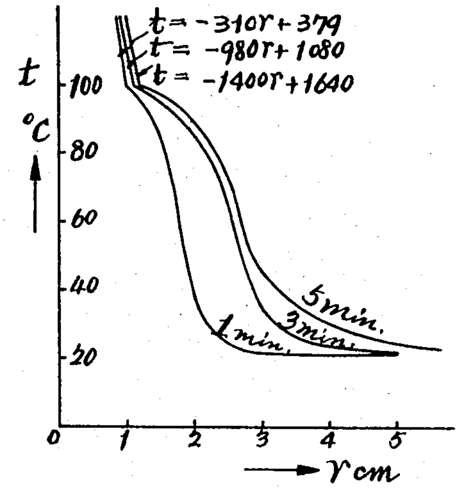


FIG. 10

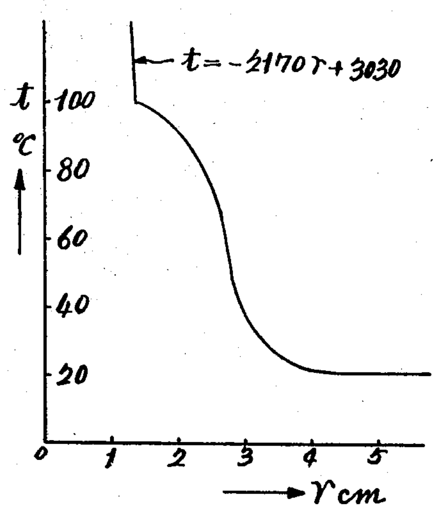
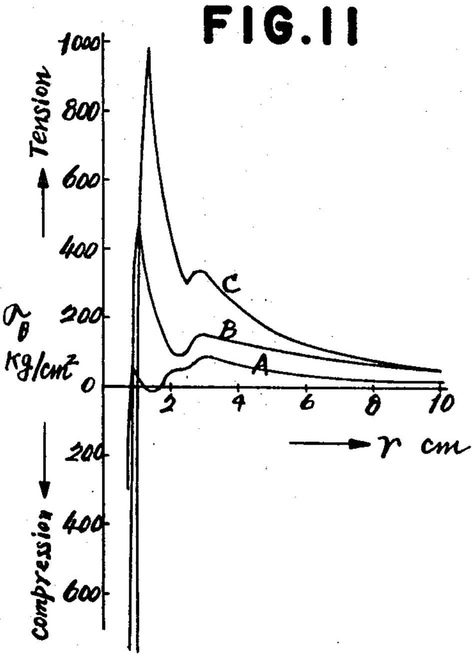


FIG. 11



METHOD OF DESTROYING FERROCONCRETE, ROCK OR THE LIKE

This invention relates to method of destroying ferroconcrete bodies, and more particularly to electrical method of destroying these bodies.

In the destruction of a ferroconcrete or reinforced concrete structure, a method of exploding it by use of explosive pneumatic force, wedge, hammer and other methods have heretofore been widely employed singly or in combinations thereof.

With the object of providing a method which can be practiced exceedingly safely, rapidly and cheaply as compared with the conventional methods of destruction, the present inventors have completed an invention of a method characterized by applying electric current to a conductor buried in advance in such a body as a ferroconcrete, and destroying such body by thermal expansion caused by generation of heat.

For example, when an iron bar of 9 mm. diam. buried in a ferroconcrete rectangular body of 15×20 cm. sectional area and 100 cm. long at about 3 cm. from its surface is connected through conductor wires to an electric source, and an electric current of 10 V. is applied to this circuit, said ferroconcrete body will be destroyed by cracking.

In the above case, the temperature of the buried iron bar becomes 800 to 1000° C. in a few minutes by its electric resistance and thermal expansion in said bar is produced in radial and longitudinal directions. As the rage of thermal expansion of iron is about 0.000013/1° C., the length of a 100 cm. long iron bar becomes approx. 101.3 cm. and the diameter of the iron bar having 9 mm. diam. becomes approx. 9.12 mm. On the other side, as the heat conductivity of concrete is 1.2—1.3 Kcal/m.h.° C. at open air drying, which is about 1/30—1/40 of iron, even when the temperature in the iron bar rapidly increases, the temperature increase in concrete is limited to the portion around the iron bar. So upon heating the thermal expansion in the iron bar buried in the concrete arises but there is practically no thermal expansion in the concrete. Moreover, at the contact portion between the concrete and iron, a physical and chemical change of concrete material arises due to the high temperature, so with its adhesion substantially eliminated. Further the tensile strength of concrete is about 1/10—1/20 of its compression strength.

As the result of these phenomena, cracking occurs in concrete due to thermal expansion of the said iron bar and the adhesion between the concrete and the iron bars decreases or disappears.

As a ferroconcrete structure is substantially unitary body because of the adhesion between the iron bar and its surrounding concrete, it is very difficult to destroy the structure by applying a mechanical force such as impact or the like, but when the adhesion between the iron bar and the concrete has been decreased or eliminated with and cracking occurring at some portions in concrete, it then becomes very easy to destroy the said structure by applying mechanical energy.

The above mentioned principle is applied in the present invention. In the use of commercial frequency of 50 to 60 c/s., a massive application of current is required for heating an iron bar or steel-frame structure (hereinafter referred to as iron and steel conductor) with the increase in the sectional area of said iron bar or steel-frame structure to be applied with electric current. As the result, the following problems occur.

1. the lead wire becomes thick and difficult to be handles;
2. the contact resistance between the lead wire and the iron and steel conductor must be decreased, with it being virtually impossible to do so; and
3. the electromagnetic force of the lead wire is enhanced.

In order to solve these problems, the present inventors have conducted experiments, and, as the result, found that with an increase in the frequency the temperature of the iron and steel conductor rapidly increases. More particularly, the present inventors have confirmed that the current flows close to the surface of the iron and steel conductor by the skin effect, and, as the result, the equivalent electric resistance of said conductor increases and the Joule loss thereof due to the same current

increases and therefore a current having far less value than in the case of commercial frequency is sufficient to obtain the same increase in the temperature.

One of the prime objects and characteristics of the present invention is to apply electric current to a conductor buried in advance in a concrete body to reduce the strength of the ferroconcrete body owing to thermal expansion of the iron and steel conductor and decrease or eliminate adhesion of the concrete to the conductor. As the result, it becomes very easy to destroy said bodies by applying a form of mechanical energy.

Another characteristic of the present invention is to apply electric current of higher frequency than commercial frequency of 50 to 60 c/s. to the buried conductor to make a higher temperature rise with far less quantity by utilizing the skin effect of electric current. As the result, the above mentioned connecting apparatus to carry a large quantity of electric current can be eliminated, and furthermore, economical profit may arise from the decrease of electric charge.

The other objects and profits may be understood by the embodiment explained with the accompanying drawings in which;

FIG. **1** is a diagram showing the relation between the frequency and the current invasion depth in the case of a flowing current to an iron and steel conductor having circular section.

FIG. **2** is a diagram showing one embodiment of a device used in the experiment of the present invention.

FIGS. **3** to **5** are diagrams respectively showing embodiments of the results of the experiments.

FIGS. **6** and **7** are diagrams respectively showing embodiments of results of other experiments.

FIG. **8** is a diagram showing the relation between temperature change at some portions in the concrete and heating time when an iron bar buried in the said concrete is heated by electric current.

FIG. **9** is a diagram showing the temperature distribution in the case of FIG. **8**.

FIG. **10** is a diagram showing the temperature distribution in the case where the iron bar is heated more rapidly than in the case of FIG. **9**.

FIG. **11** is a diagram showing the stress distribution in the case of FIG. **9** and FIG. **10**.

FIG. **1** is a graphical representation showing the relation between the frequency f and the current invasion depth δ in the case of flowing the current to the iron and steel conductor of circular section using permeability μ as a parameter. In this case, the following formula can be established.

$$\delta = \frac{1}{\sqrt{\pi f \mu K}} m$$

$$K = 5.92 \times 10^{6} \nu m$$

Accordingly, with the increase in the frequency, the sectional area of flowing current decreases and hence the effective resistance increases. In order to obtain the same increase in the temperature, less current will be sufficient with the increase in the frequency and it is expected that defects caused by said larger current can be removed.

FIG. **2** shows one example of an experiment device used in the present invention. Reference numeral **1** designates a DC motor, **2**, an induction frequency converter, **3**, an autotransformer, **4**, a transformer for heating, and **5**, an iron bar for heating experiment. More particularly, the frequency is converted by the induction frequency converter **2** and introduced into the autotransformer **3**, thus the secondary side voltage of the transformer for heating being controlled. The iron and steel conductor **5** was heated in air within the windless chamber. The heating temperature was measured by contacting copper with constantan. Also, with respect to the flowing current of the iron and steel conductor **5** the induction voltage of search coil was measured by a vacuum tube voltmeter. In order to avoid the variation of permeability by high temperatures, the flowing current was fixed to a relatively small value of 120 A., and with respect to various size and type of iron and steel conductors the relation between the current and the increase in the temperature was sought by using the frequency as a parameter. The results are shown in FIGS. **3** to **5**. The vertical axis shows the temperature of the iron and steel conductor (°C), and the transverse axis shows the flowing current time (minute). FIG. **3** shows the case of heating a round steel bar (nominal diameter: 9 mm.), and FIG. **4** the case of heating a round steel bar (nominal diameter: 19 mm.). In these cases, comparing the temperature 2 minutes after the commencement of flowing current in cases of 200 c/s. and 60 c/s., the former is about 3.3 times as large as the latter in case of the diameter 9 mm. and the former in about 5 times as large as the latter in case of the diameter 19 mm. FIG. **5** shows the case of heating an equilateral angle steel (nominal dimension: 40×40 ×5). About the same tendency as the foregoing can be recognized.

FIG. **6** indicates the relation between the current and the impedance, i.e. the result obtained by measuring it at the frequency of 50 c/s. by placing iron bars (diameters: 9 mm., 13 mm. and 16 mm.) in water to control the increase of the temperature. As is evident from the drawings, with the increase in the current the impedance decreases. This is considered to be caused by the fact that the increase in the magnetic field due to the increase in the current causes the permeability to decrease and affects the skin effect. In the drawing "**16 Φ Rdc**" shown by dotted line indicates the DC resistance of an iron bar having a diameter of 16 mm. and is shown for comparison's sake. Compared with this, the impedance is indicated about 4.2 times at the value of 300 A. and about 3.3 times at the value more than 700 A. even in the case of frequency 50 c/s. Further, power factor on this occasion showed a value of about 0.95.

FIG. **7** shows the results of an experiment carried out by using a relatively small current at the frequency 200 c/s. It can be inferred from this that with the increase in the frequency the skin effect is increased further.

Further, consideration must be taken in the iron loss as a factor for increasing effective resistance. If the frequency is definite, hysteresis loss increases in proportion to the raise to 1.6st or 2nd power of magnetic flux density and hence it is not suitable for explaining the relation between the current and impedance shown in FIG. **6**. The impedance characteristic on this occasion is considered that the decrease in the permeability due to the increase in the current affects the skin effect.

From the aforementioned results of experiments, it is found that, in case of directly heating an iron and steel conductor having a large sectional area by flowing current, a small current is sufficient to raise the temperature as desired by elevating the frequency in utilization of the skin effect, and therefore it has been found that the present method is effective.

FIG. **8** shows the relation between temperature change at some portion in the concrete and heating time when an iron bar of 16 mm. diam. buried in the concrete is heated by applying electric current of a constant electric power. The temperature was measured by a copper-constantan instrument previously buried in the concrete at a distance of *d* cm. from the surface of the iron bar. In this FIG., the temperature in the concrete does not exceed 100° C. which is understandable from the fact that the moisture, which is always contained in any quality of concrete, takes evaporation heat from the concrete.

FIG. **9** is a diagram showing the temperature distribution in the concrete at a point *r* cm. from the central axis of the iron bar and in the case of FIG. **8** at 1 minute, 3 minutes, and 5 minutes after applying electric current. The high temperature part (over 100° C.) is shown by approximation formula.

FIG. **10** shows the temperature distribution in the case where the iron bar is heated more rapidly than in the case of FIG. **9**.

FIG. **11** is a diagram showing the stress distribution in circumferential direction of 20 cm. diam. concrete cylinder in the case of FIGS. **9** and **10**. The stress was estimated from the stress caused by thermal expansion of the iron bar considerating the displacement of concrete by thermal expansion and from the thermal expansion stress of concrete itself. The curve A shows the stress distribution in the case of FIG. **9** at 2 minutes after applying electric current; curve B shows the same at 5 minutes after; curve C shows the stress distribution in the case of FIG. **10** at 2 minutes after applying electric current. Assuming the tensile strength of concrete is 50 Kg/cm.^{2}, the cracking stress exits at 4.7 mm. from the center at curve A, but the cracking stress reaches to the cylinder surface at curve C in the same heating time with curve A.

It is obvious that in the case of curve B it takes over 5 minutes to make the same effect of the case of curve C, and it is also obvious that the case of FIG. **10** is more excellent in cracking length, number of cracks and time requiring for causing cracks than in the case of FIG. **9**.

As is evident from the aforementioned explanation, in the present invention the frequency of current employed is increased whereby the current value for causing the temperature rise is decreased by utilizing the skin effect to make it easily adapted to the spot operation. It is preferably to select the frequency between 100 to 500 c/s. With the progress in electric equipments it is possible to use a current of approximately 10,000 c/s., whereby it may be more effective.

Furthermore, as is evident from the foregoing explanation, since the portion to be heated as the result of skin effect is limited to a portion close to the surface, the iron and steel conductor to be buried later for destruction is not always a core body and it is also possible to use a tubular body in the present invention.

Although one embodiment of the invention has been shown and described in detail, it will be understood that other embodiments are possible and that various changes may be made in the design and arrangement of the parts without departing from the spirit of the present invention.

We claim:

1. The method of destroying a ferroconcrete body formed of a concrete mass having metal reinforcements embedded therein, said method comprising the application of an alternating electric current directly to the metal reinforcement, applying said current for a sufficient time to heat said metal reinforcements to produce a thermal expansion of said reinforcements thereby cracking the surrounding concrete and substantially reducing the adhesion between the metal reinforcements and the concrete.

2. The method of claim **1** wherein said electric current has a frequency of 50 to 60 cycles per second.

3. The method of claim **1** wherein said electric current has a frequency of 100—1000 cycles per second.

4. The method of claim **1** wherein said elastic current has a frequency of up to 10,000 cycles per second.

5. The method of claim **4** wherein said metal reinforcements are steel rods.