Springs for Telephone Apparatus

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THE many types of springs necessary to fill the manifold needs of telephone apparatus comprise both non-ferrous and steel springs, of sheet metal and of wire. Proper functioning of all these can be ensured only by care in their design and in the selection of their material. In many instances springs must occupy but small space, yet must maintain delicate adjustment, with a minimum of attention, throughout the life of the apparatus. The forces on springs are sometimes large, and space limitations require that the springs operate under comparatively large unit stresses.

By far the most numerous are the sheet non-ferrous springs, usually consisting of punched and formed parts made from brass, nickel-silver, or phosphor bronze. Some are employed statically — to maintain constant pressure for long periods — but more are subject to successive deflection, electro-magnetically or mechanically. The latter are essentially cantilever springs, clamped at one end; they are used in switchboard keys (Figure 1), subscribers' dials (Figure 2), relays, jacks, interrupters and switches. The fixed end is customarily clamped between strips of phenol fiber, a good insulator, mechanically strong, and permanent in form. When used as contacting members, they bear one or more precious-metal contacts spot-welded in place near the operating end. The precious-metal contacts are employed to reduce contact resistance and the destructive effects of arcing when circuits are broken. When used as brushes or wiping members, the spring material itself usually serves for the contacting and wearing parts. To springs that form part of electrical circuits, the connections are soldered, usually to lugs which form part of the spring and project from it at the end of the clamped area opposite its operated end.

The properties required of these small springs are numerous and vary for each type of application. The proportional limit* must not be too high to prevent adjusting the spring by flexing it with a tool to the point where it takes a set and occupies a position in which it provides the desired operating pressure. In other words, there must be room enough to flex the spring to the point where it will take a set within the space provided. A spring of high proportional limit, such as one of clock-spring steel, may be bent nearly double without being permanently deformed. Obviously, such a spring could not be adjusted in the key shown in Figure 1.

The modulus of elasticity should be within the range of twelve to twenty million pounds per square inch in order that the load-deflection rate will not be too steep to permit reasonable ease of adjustment by hand.

If telephone-apparatus springs were

* *The proportional limit is the stress beyond which deflection is not proportional to stress.*

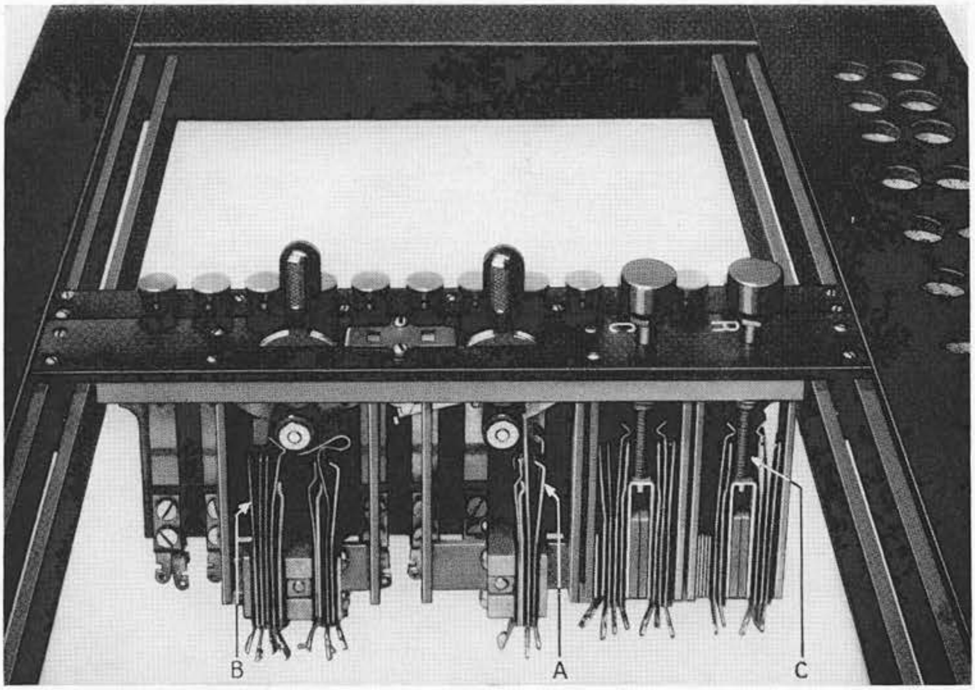

Fig. 1—Switchboard keys frequently embody wiping springs (A), contact-carrying springs (B), and helical compression springs (C)

not carefully designed to have as large a factor of safety as possible, there would be numerous cases of fatigue failure. All metals thus far investigated have an "endurance limit", a maximum stress which may be repeated indefinitely without failure. A stress above this limit, if repeated often enough, will lead to eventual failure. The effect is cumulative and the failure occurs quickly in seemingly sound metal that has functioned satisfactorily for years. Only recently, after completing a few preliminary fatigue tests on sheet metal, has the full significance of this property been realized. It has been shown that the ratio of the endurance limit to the ultimate tensile strength varies from .15 to .36 for brass, nickel-silver and phosphor-bronze sheet, and that for steel the ratio varies from .40 to .60. It is important, therefore, to know the endurance limit of non-ferrous sheet-metal springs in order to determine whether a design provides a sufficient margin of safety.

"Creep", or deformation under sustained load, must not take place, since the material will lose tension. Brass, nickel-silver, and phosphor bronze may be expected on the basis of years of experience to hold adjustments when stressed up to approximately their proportional limits. Other materials when considered for telephone apparatus springs are investigated to determine their "creep" characteristics.

"Season cracking"*, or spontaneous failure of a metal under prolonged stress, takes place with some brasses

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under high sustained stress and severe atmospheric conditions, and therefore springs that are required to hold their pressure for long periods under these conditions are not made from this material. Nickel-silver will also season-crack under still higher sustained stress and more severe corrosive conditions; phosphor bronze is least susceptible of all. In designing these springs, generous fillets and easy curves are employed to prevent the building up of localized high stresses that may lead to season cracking under sustained load and fatigue failure under repeated flexure.

When springs are used as wipers in electrical circuits where arcing can occur, brass and nickel-silver are not employed because the heat of the arc breaks down the material, volatilizes the zinc, and disintegrates the spring. For springs so used, phosphor bronze, which does not contain zinc and has wear resistance superior to brass and nickel-silver, is therefore employed.

Springs must also be resistant to atmospheric corrosion and capable of readily alloying with soft solder. Nickel-silver is superior to brass in its mechanical properties, and may be readily spot-welded; as a result of years of experience it has been found that springs made of this material are capable of maintaining adjustment in a satisfactory manner in service. Phosphor bronze has still greater wear resistance than brass or nickel-silver and superior spring properties.

Springs of clock-spring steel are used as vibrating elements in interrupters, where a high fatigue endurance is required, and for springs that must be worked at high pressure and rapid build-up of pressure. These springs are made from carbon-steel, heat-treated and then cold-rolled, and are by nature brittle. To guard against excessive brittleness and at the same time provide a high strength, a bend test has been developed. It requires that when the material is bent

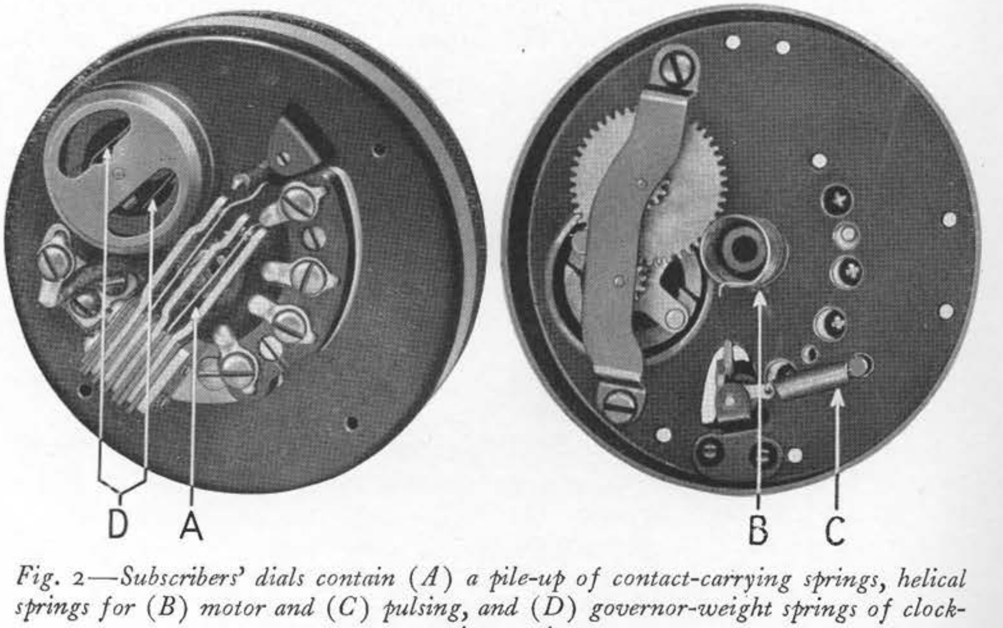

Fig. 2—Subscribers' dials contain (A) a pile-up of contact-carrying springs, helical springs for (B) motor and (C) pulsing, and (D) governor-weight springs of clock-spring steel

back parallel to itself to form a "U" and further compressed between flat parallel surfaces (for example, between the jaws of a vise), the material shall not break when compressed a certain distance but must break when compressed further. The test can be conveniently applied by drawing the looped material through two of a series of graduated slots.

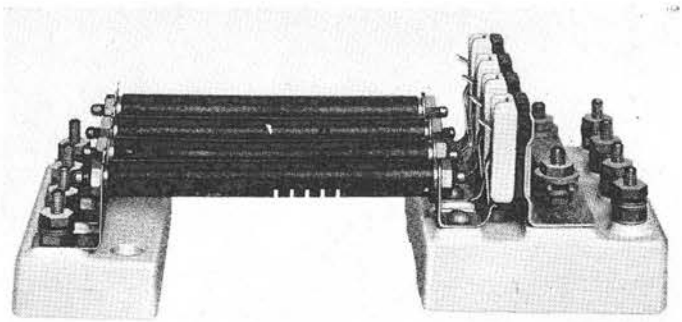

Fig. 3—In the protector, nickel-silver springs hold the protector blocks in place

Tinned and plated music wire is extensively used for compression springs in telephone apparatus. Here the spring is in the form of an open helix, and is either tinned or plated with nickel. The average tensile properties of the music wire employed are: proportional limit, 217,000 pounds per square inch; ultimate tensile strength, 350,000 pounds per square inch. No chemical or tensile requirement is placed on this wire, the main feature of concern being brittleness. The elongation measured in an eight-inch length must be between one and four per cent for heavy wire (up to and including No. 27 gauge) and one-and-one-half to seven per cent for No. 28 gauge wire and lighter. A kinking test, in which No. 30 wire and smaller shall kink without breaking, also indirectly controls its tensile properties.

Vast quantities of springs are employed in the telephone plant, and numerous factors must be considered when selecting materials for them. The materials generally used have abundant sources of supply, and the quality is carefully controlled by tests that are designed to be easy to apply and effective in evaluating the properties desired.