

Nov. 25, 1947.

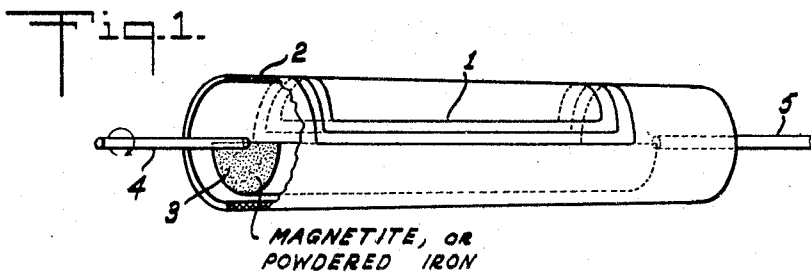
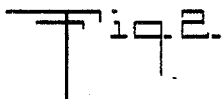
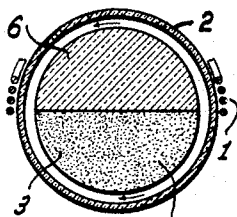
W. F. SANDS

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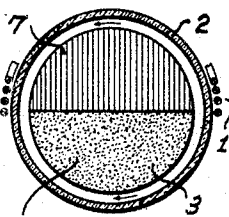
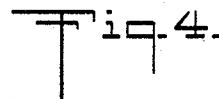
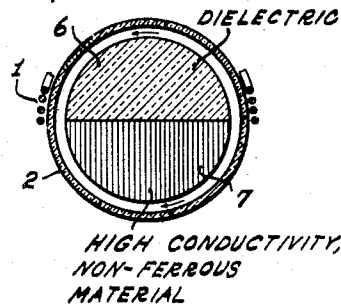
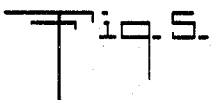
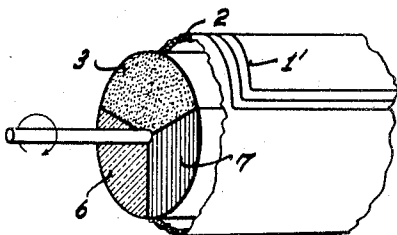
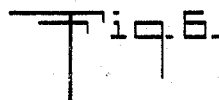
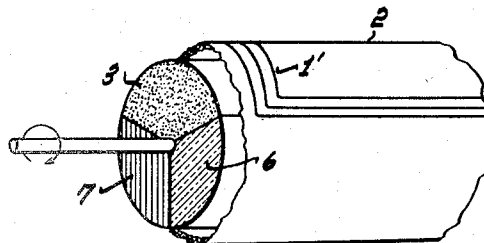
VARIABLE INDUCTANCE DEVICE

Filed Feb. 5, 1944

2 Sheets-Sheet 1



MAGNETITE, OR
POWDERED IRON



INVENTOR

WILLIAM F. SANDS

BY

H. G. Grover

ATTORNEY

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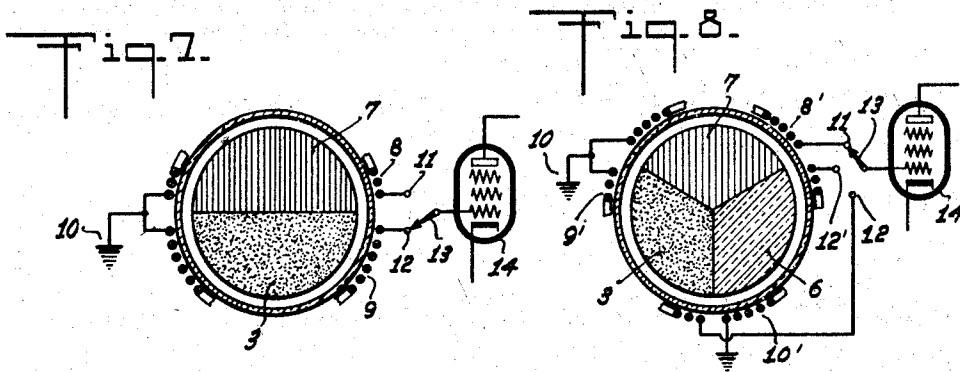
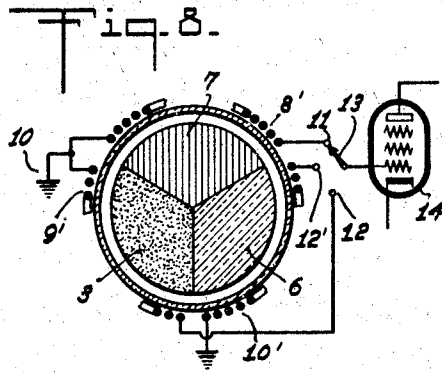
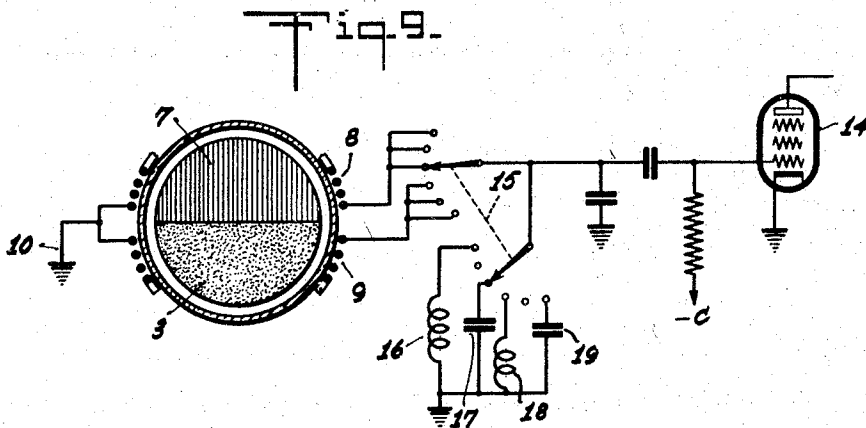
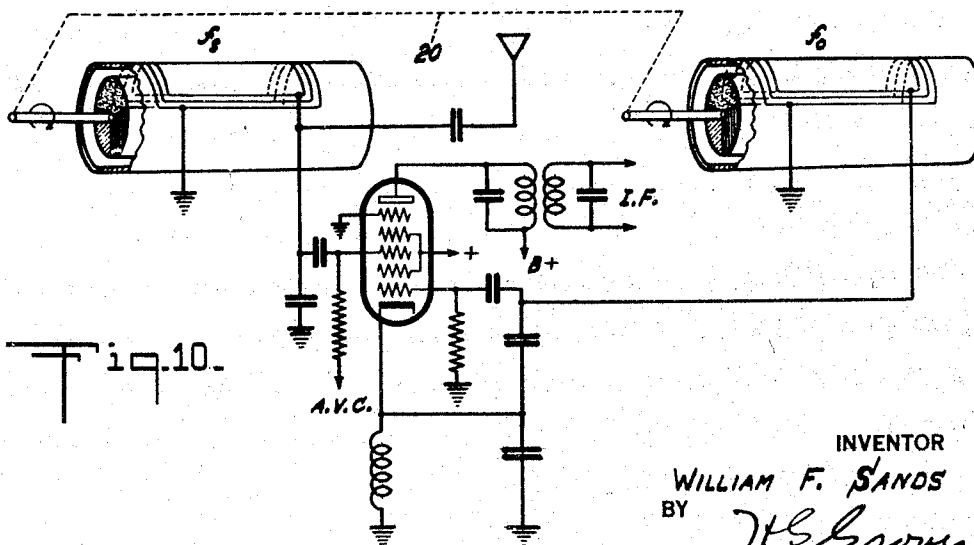
W. F. SANDS

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VARIABLE INDUCTANCE DEVICE

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2 Sheets-Sheet 2



INVENTOR

WILLIAM F. SANDS

BY

W. S. Brown

ATTORNEY

UNITED STATES PATENT OFFICE

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VARIABLE INDUCTANCE DEVICE

William F. Sands, Haddonfield, N. J., assignor to
Radio Corporation of America, a corporation of
Delaware

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12 Claims. (Cl. 171-777)

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The present invention relates to a variable inductance device, and more particularly to a high frequency inductance device of the permeability tuned type in which relative movement of a magnetic core and an inductance coil serves to change the inductance of the coil for tuning or other purposes.

It is common practice in devices of this type to provide a solenoid type of inductance wound around a cylindrical coil form and a similarly-shaped magnetic core which is movable axially or longitudinally within the coil form, so that as the core is moved through its range of travel there is introduced into the field of the coil varying amounts of the core to increase correspondingly the inductance value of the coil.

Where space is an important factor in the design of radio apparatus, such as receivers of the portable type, permeability tuned coils of the above-mentioned type do not readily lend themselves to compactness and simplicity, since sufficient clearance must be allowed for the linear core travel which is generally from one to two inches.

It is, therefore, one of the objects of the present invention to provide a novel, variable inductance coil and core combination which does not require longitudinal displacement of the core with respect to the coil for effecting inductance changes, but rather an angular displacement of the core.

Another object is to provide a core composed of a plurality of sectors having different permeabilities and a fixed coil so wound upon a partial surface of revolution that the coil undergoes a wide change in inductance upon rotation of the core.

A further object is to provide a multiplicity of coils wound on a surface of revolution, each on a different portion thereof and operating in a different frequency range, and a core composed of sectors having different permeabilities, the combination being suitable for use as the tuning device in multi-band receivers.

These and other objects and advantages of the invention will be apparent from the following specification when taken with the accompanying drawings; in which:

Fig. 1 is a view in perspective of the novel core and coil combination constituting the variable inductance device in accordance with the invention;

Figs. 2, 3 and 4 are views in cross-section showing modified forms of the variable inductance device disclosed in Fig. 1;

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Figs. 5 and 6 are views in perspective of still further modifications;

Figs. 7 and 8 disclose arrangements adapted for multi-band operation, utilizing respectively the composite cores of Figs. 3 and 5;

Fig. 9 is a modification of the system disclosed in Fig. 7, for multi-band operation; and

Fig. 10 discloses the use of a pair of ganged variable inductors according to the invention in a receiver circuit of the superheterodyne type.

Referring now to the drawings wherein like reference characters represent the same or corresponding parts in all of the figures, a variable inductor embodying the basic idea of the invention is disclosed in Fig. 1 and comprises a coil 1 wound on a tubular, cylindrical coil form 2, within which there is coaxially disposed a semi-circular core 3 of magnetite or powdered iron, it being understood that such cores are commonly formed by molding the magnetite or powdered iron with suitable binding material. The core is constrained against axial or longitudinal movement by suitable means, not shown, but is capable of rotational movement by means of suitably journaled shafts 4, 5 extending from the opposite ends of the core, one of which may be provided with a control member for effecting angular adjustment of the core which constitutes the variable tuning element of the inductor.

The coil 1 is preferably rectangular in shape and is so wound on the coil form that it occupies only an arcuate portion of the surface. As shown in Fig. 1 the shorter sides of the coil extend over an arc of substantially 180 degrees and the other two sides extend in an axial direction. In the illustrated position of the core with respect to the coil, wherein the core is so disposed as to have a minimum interlinkage with the magnetic field of the coil, the coil inductance will be at a minimum in the presence of the core. Upon rotation of the core in either direction increasing amounts thereof will be introduced into the field of the coil to thereby gradually increase the inductive value of the coil until, when the core has been rotated through 180 degrees to be completely contained within said field, the coil inductance will be at a maximum. It will be seen that the maximum tuning range will be secured for Fig. 1, and indeed for each of the modifications to be described hereinafter, when the coil form has a very small wall thickness and the core diameter is such as to provide only a very slight clearance to the inside surface of the coil form.

The variable inductor of Fig. 2 is similar to that of Fig. 1 except that in addition to the semi-

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circular section 3 of ferro-magnetic material, the core is provided with a second semi-circular section 6 of suitable dielectric material. The core of Fig. 2 is the electrical equivalent of the core shown in Fig. 1, since the latter may be considered to possess a second or dielectric portion of air. However, for practical and structural reasons the core of Fig. 2 is to be preferred since the dielectric portion 6 of the core serves as a counter-balance for the magnetite or powdered iron portion which will cause the core to be retained in any of its positions of adjustment.

The variable inductor disclosed in Fig. 3 makes use of a core which comprises two semi-circular portions 3 and 7, the former consisting of magnetite or powdered iron, and the latter of a high conductivity, non-ferrous material, such as copper or brass. The use of a core material of high conductivity is not, in general, advisable for use in the broadcast band due to severe loss in the "Q" or figure of merit of the circuit. However, at higher frequencies, particularly above 20 megacycles, the use of a core material of high conductivity does not cause such loss in Q. Consequently, the inductor of Fig. 3 is suitable for use in high frequency circuits whereas that of Fig. 1 or 2 may be used for frequencies in the broadcast range, or lower.

Since the effect of introducing a core of magnetic material into the field of a coil is to increase the inductance of the coil, whereas the effect of a high conductivity, non-magnetic core is to decrease the coil inductance, it is possible with the composite core structure of the type disclosed in Fig. 3 and others to obtain a wide range of inductance variation of the coil. The variable inductor of Fig. 4 is also suitable for use at high frequencies, the core thereof comprising a portion 7 of high conductivity, non-ferrous material and a portion 6 of dielectric material.

In Fig. 5 the coil 1' extends over an arcuate portion of the coil form 2 for about 120 degrees and the core is composed of three longitudinal sections of different permeabilities, namely, a section 3 of magnetite or of powdered iron, a section 6 of dielectric, and a section 7 of high conductivity, non-ferrous material, each extending for the full length of the core and occupying an arc extending for substantially 120 degrees. The maximum range of inductance variation of the coil as shown in Fig. 5, and hence its tuning, may be performed by a total rotation of only 240 degrees as follows: Beginning with the core at the position shown where the sector of iron coincides with the winding, the inductance is a maximum. As the iron is withdrawn and more of the dielectric is introduced, assuming clockwise rotation of the core, the inductance is gradually decreased until at the end of rotation through 120 degrees the whole of the dielectric sector coincides with the winding at which position the inductance will be substantially that of the coil in the absence of the core. With continued core rotation the dielectric is withdrawn and the core sector of high conductivity, non-ferrous material is introduced to cause thereby a further gradual decrease in the coil inductance until at the end of the second 120 degree rotation the hole of the high conductivity core sector coincides with the winding at which final position the coil inductance will be a minimum.

An alternative core assembly is shown by Fig. 6 in which the sector 7 of non-ferrous material and the sector 6 of dielectric material are interchanged. The tuning may then be performed by

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a total core rotation of only 120 degrees as follows: from the position shown (where the iron coincides with the winding), through an intermediate region in which varying portions of both sectors 6 and 7 are positioned under the winding, until finally the high conductivity non-ferrous sector 7 coincides with the winding. It is evident that the shape of the tuning curve and of the variation of "Q" curve will be quite different for the structures of Figs. 5 and 6. If desired, the high conductivity portion may be omitted for use on lower frequency bands with a resulting operation over only 120 degrees of rotation (as for Fig. 6).

By mounting two or more coils on different portions of the cyclical coil form, the present invention may be adapted for multi-band operation. Two such modifications are disclosed in Figs. 7 and 8 for two-band and three-band operation, respectively. In Fig. 7 the two coils 8 and 9 are disposed each on opposite half-portions of the coil form and are operative in two different frequency bands, one of which may be a relatively low frequency band and the other a high frequency band, or both may be high frequency bands, such as, for example, the international short-wave entertainment bands. One pair of adjacent ends of the coils 8 and 9 are jointly connected to ground at 10, and the other pair of coil ends are individually connected to terminal contacts 11 and 12. By means of a switch 13, one or the other of coils 8 and 9 is adapted for connection to the signal control grid of an electron discharge tube 14 which may be a radio frequency amplifier or a converter. Although a core composed of a magnetite or powdered iron portion 3 and a high conductivity, non-ferrous portion is shown in Fig. 7, it is obvious that the core could also be made up of a section 3 and a dielectric section 6, or else of sections 6 and 7.

The arrangement of Fig. 8 is similar to that of Fig. 7 except that it is adapted for operation in three frequency ranges. In this case there are employed the composite core of Fig. 5 composed of sectors 3, 6 and 7 and three coils 8', 9' and 10' which extend each through an arc of 120 degrees. The coils 8' and 9' are similarly connected to ground and to the switch terminals 11, 12 as the coils 8 and 9 in Fig. 7, the third coil 10' having one end connected to ground and its other end to a terminal contact 12' for cooperation with the movable switch arm 13. The manner of operation of Fig. 8 will be clear from the description given above. The tuning for each band is performed by a total rotation of 240 degrees as for the arrangement of Fig. 5. If desired, however, a core such as used for Fig. 6 may be used in the multi-band assembly of Fig. 8. Similarly, where the tuning across each individual band is to be performed with a rotation of only 120 degrees, either a section 3 or a section 7 may be used with a 240 degree section of dielectric material (i. e., double section 6). If desired, the sections of different permeability may be used to tune different bands. Thus, the high-conductivity, non-ferrous section may tune a very high frequency band and a magnetite or powdered iron section used to tune another winding across a lower frequency band. A possible variant of this is the use of two 120 degree magnetite or powdered iron sections having quite different magnetic properties for tuning different windings across relatively high and lower frequency bands, and the third section of the core may be of dielectric material.

For any of the foregoing arrangements, additional bands may be covered merely by switching various capacitors across the coil, or by connect-

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ing suitable series and/or shunt coils across the coil. By way of illustration only, one such circuit is shown in Fig. 9 in which the variable inductor assembly of Fig. 7 is used in connection with a six-position band-switch 15 to cover a total of six bands. As shown, coil 8 is adapted in the first position of the switch to have shunted thereacross a coil 16 and in the third position a condenser 17. Similarly, the coil 9 is adapted in the fourth and sixth switch positions to have a coil 18 and a condenser 19 connected in shunt therewith, respectively. In the second and fifth switch positions, the respective coils alone determine two of the frequency bands.

Although all of the foregoing describes the use of a single assembly, it will be evident that two or more of the above units may be "ganged" by suitable mechanical means for use in radio receivers such as the conventional tuned radio frequency (T. R. F.) type or the generally-employed superheterodyne receivers. Thus, one assembly may be used in the antenna stage (or signal frequency circuit) while another may be employed in the local oscillator circuit. One such arrangement is shown by way of example in Fig. 10 which shows the variable inductors f_s and f_o uncontrolled by mechanical means represented by the dotted line connection 20 and included respectively in the signal frequency and oscillator circuits of a conventional converter stage in a superheterodyne circuit.

It will be apparent also that the inductance devices according to the invention may be coupled or "ganged" by suitable mechanical means to rotatable type variable capacitors. Indeed, where the shape of the active plates, or the dielectric surfaces, of the rotatable capacitor are arcuate sections of a cylindrical surface, then the entire assembly may be mounted in a coaxial manner. The variable inductor and the variable capacitor may be connected in the same circuit to give an extended tuning range, or they may be connected in separate circuits. For example, the variable capacitor may be used to most efficiently tune the loop antenna circuit, while the variable inductor may be used to tune the oscillator circuit of the receiver.

While I have shown and described several preferred embodiments of the invention, it will be understood by those skilled in the art that modifications and changes may be made without departing from the spirit and scope of the invention.

What I claim is:

1. A variable inductor comprising a tubular coil form, a coil wound on said coil form and occupying only a partial surface of revolution of the form, and a core coaxially mounted with respect to the coil form having such configuration that upon rotation thereof there are introduced into the field of the coil varying portions of the core, said core having the property of affecting a change in the inductance of the coil.

2. A variable inductor comprising a tubular coil form, a coil wound on said coil form and occupying only a partial surface of revolution of the form, and a composite core of sectors having different permeabilities coaxially mounted with respect to the coil form, said core adapted upon rotation to have varying portions of the core sectors moved into the field of the coil to thereby affect variations in the inductance of the coil.

3. A variable inductor comprising a tubular coil form, a coil wound on said coil form and occupying only a partial surface of revolution of

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the form, and a ferro-magnetic core substantially semi-circular in cross-section coaxially mounted with respect to the coil form, said core adapted upon rotation thereof to have varying portions of the core introduced into the field of the coil to thereby vary the inductance of the coil.

4. A variable inductor comprising a tubular coil form, a coil wound on said coil form and occupying only a partial surface of revolution of the form, and a cylindrical core having at least one portion of ferro-magnetic material and another of high conductivity, non-ferrous material coaxially mounted with respect to the coil form, said core adapted upon rotation thereof to have varying portions of each core portion introduced into the field of the coil.

5. A variable inductance device comprising a hollow cylindrical coil form, a coil of rectangular shape wound on said form and having its two opposite short sides in the form of an arc and its two other longer sides extending in an axial direction, and an inductance-changing core coaxially disposed within the coil form and adapted for rotational movement whereby varying portions of the core are introduced into the field of the coil to vary its inductance.

6. A variable inductance device comprising a hollow cylindrical coil form, a coil of rectangular shape wound on said form and having its two opposite short sides in the form of an arc and its two other longer sides extending in an axial direction, and an inductance-changing core composed of a plurality of sectors, each of a different permeability, coaxially disposed within the coil form and adapted for rotational movement whereby varying portions of the core sectors are introduced into the field of the coil to vary its inductance.

7. A variable tuning instrumentality for use in a multi-band receiver, comprising a hollow cylindrical coil form, a plurality of coils so disposed on said form as to occupy different arcuate portions thereof, a core composed of a plurality of sectors, each of a different permeability, disposed in concentric relation with respect to the coil form and to the several coils as a group, means for selectively connecting one of said coils into circuit, and means for rotating the core to successively introduce its sectors of different permeabilities into the field of the selected coil.

8. A variable tuning instrumentality for use in a multi-band receiver, comprising a hollow cylindrical coil form, relatively high and low frequency coils so disposed on said form as to occupy different arcuate portions thereof, a cylindrical core composed of two longitudinally extending portions, each semi-circular in cross-section and of different permeability, said core being disposed in concentric relation with respect to said coil form and to the several coils as a group, the core portions of higher and lower permeabilities being cooperatively related respectively with the low frequency and high frequency coils, means for selectively connecting one of said coils into circuit, and means for rotating the core to effect inductance variations of the selected coil due to the angular adjustment of its associated core portion.

9. A variable tuning instrumentality as defined in claim 8 wherein the core portions consist respectively of powdered iron and of high conductivity, non-ferrous material.

10. A variable tuning instrumentality for use in a multi-band receiver, comprising a cylindrical coil form, relatively high and low frequency coils

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so disposed on said form as to occupy different arcuate portions thereof, a cylindrical core composed of three longitudinally extending portions, each extending over substantially 120° of arcuate section and of different permeability, means for selectively connecting one of said coils into circuit and means for rotating the core to successively introduce its portions of different permeabilities into the field of the selected coil.

11. A variable tuning instrumentality for use in a multi-band receiver, comprising a cylindrical coil form, relatively high and low frequency coils so disposed on said form as to occupy different arcuate portions thereof, a cylindrical core composed of three longitudinally extending portions, each extending over substantially 120° of arcuate section and of different permeability, said core being disposed in concentric relation with respect to the coil form and to the several coils as a group, the core portions of higher and lower permeabilities being cooperatively related respectively with the low frequency and high frequency coils, means for selectively connecting one of said coils into circuit, and means for rotating the core to effect inductance variations of the selected

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coil due to the angular adjustment of its associated core portion.

12. A variable tuning instrumentality as defined in claim 11 wherein the core portions consist respectively of powdered iron, of dielectric material, and of high conductivity, non-ferrous material.

WILLIAM F. SANDS.

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