Oct. 9, 1962 L. T. BARNES 3,058,042

ADJUSTABLE ELECTRICAL REACTANCE UNIT

Filed Sept. 21, 1959

FIG. 1

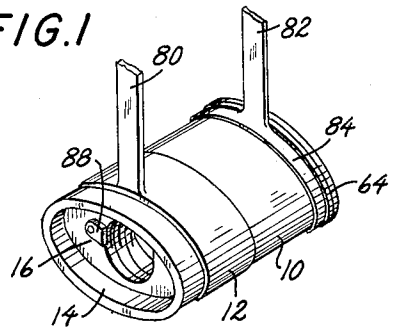


FIG. 5

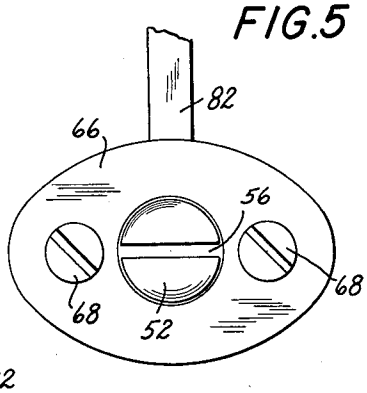


FIG. 2

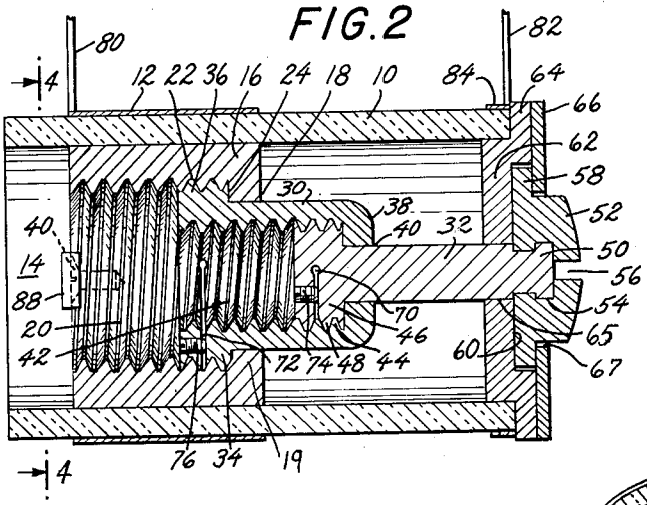


FIG. 4

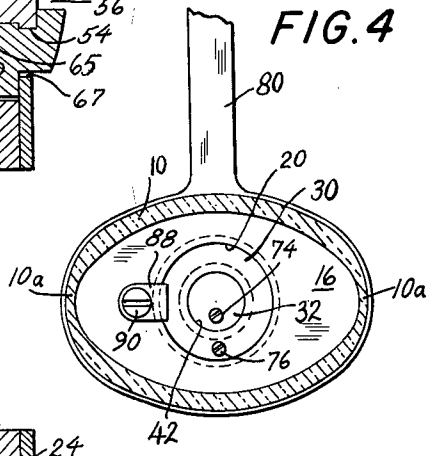
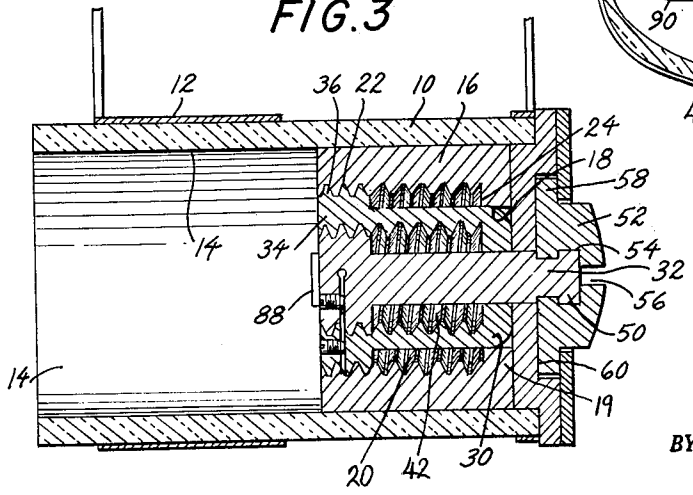


FIG. 3



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ADJUSTABLE ELECTRICAL REACTANCE UNIT

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11 Claims. (Cl. 317—249)

The present invention relates to improvements in adjustable electrical reactance units, and in particular relates to a miniature unit having a movable piston-type electrode actuated by screw means, for example, a trimmer capacitor.

In many electronic installations, adjustable reactance units of the trimmer type are widely employed, and it is desirable to provide very fine and accurate adjustment of the units with a minimum of back-lash. For purposes of fine tuning, it is also desirable to minimize accidental creepage or movement of the piston due to shock or vibration. With the constant tendency toward greater miniaturization of circuits, it has become increasingly desirable to make these reactance units as small as possible and still maintain the maximum range of reactance.

As the term is used herein, I intend to encompass under the term "reactance unit" such variable electric units as trimmer capacitors, resistors, inductors and the like. In my prior United States Patent No. 2,607,826, issued August 19, 1952, I have disclosed such an adjustable reactance unit in the form of a trimmer capacitor having a spring-loaded piston and screw assembly. In the present invention, I have eliminated all springs, and employ friction means to produce fine screw adjustment.

In accordance with the present invention, there is provided a trimmer-type reactance unit having a movable electrode in the form of a piston which slides within a hollow housing. The piston is actuated by a screw which is turnable within an intermediate member, the latter in turn having a screw engagement with the piston. The screw, intermediate member, and piston all telescope with one another to move the piston upon turning of the screw.

An object of the invention is to provide an adjustable reactance unit of the character described in which the piston and the interior of the hollow housing are made elliptical in shape so as to provide for sliding movement of the piston without rotation thereof, and in addition provide a maximum effective area of reactance between the piston electrode and the fixed electrode.

Another object of the invention is the provision of an adjustable electrical reactance unit of the character described in which adjustment means are provided for varying the frictional drag on the screw-threaded elements and thereby produce an optimum degree of fine linear movement of the piston.

Still another object of the invention is the provision of an adjustable reactance unit of the character described incorporating improved adjustment means for the piston, the adjustment means being so constructed as to provide the highest approach to linear tuning with ultra-fine resolution and a minimum of back-lash.

A further object of the invention is the provision of an adjustable reactance unit of the character described which provides a long travel of the piston with no axial movement of the adjusting screw, and consequently a decrease in overall length of the unit.

Additional objects and advantages of the invention will become apparent during the course of the following specification when taken in connection with the accompanying drawings, in which:

FIG. 1 is a rear perspective view of a trimmer condenser made in accordance with the present invention;

FIG. 2 is an enlarged longitudinal section of the trimmer condenser of FIG. 1 taken through the center thereof and showing the piston in its fully extended position;

FIG. 3 is an enlarged section, similar to FIG. 2, but showing the trimmer condenser with the piston in a fully retracted position;

FIG. 4 is a transverse section taken along line 4—4 of FIG. 2; and

FIG. 5 is a front elevational view of the trimmer condenser.

Referring now specifically to the drawings, the invention herein is shown applied to a variable condenser of the trimmer type. The condenser has a hollow body **10** made of a material having a high dielectric constant and preferably a low coefficient of thermal expansion, example of such materials being quartz, glass, polystyrene or the like. The body **10** is made of elliptical or oval cross-section, rather than circular shape, for purposes which will be presently explained.

The condenser body **10** has on its outer surface a fixed electrode **12** which may be in the form of a band of conductive metal bonded to said outer surface, or which may be in the form of a silver layer fired on said surface. The hollow condenser body **10** also defines a through bore **14** of elliptical shape.

A movable electrode, in the form of a piston **16** is also of elliptical shape and is sized to fit slidably within the bore **14** of body **10**. The piston **16** has an end wall **19** having a circular opening **18** communicating with a bore **20** of circular cross-section and larger diameter which bore extends to the opposite end of said piston **16**. The bore **20** is provided with internal threading **22**, and forms with the smaller opening **18**, a shoulder **24**.

Drive means are provided for sliding the piston **16** longitudinally within the dielectric body **10** and relative to the fixed electrode **12**, whereby to vary the capacitance of the condenser. Such drive means includes an intermediate cylindrical member **30** and a drive shaft **32**.

The cylindrical member **30** has an enlarged end portion **34** bearing external threading **36** which is sized to mesh precisely with the internal threading **22** of piston **16**. The main body portion of cylindrical member **30** is sized to fit slidably and rotatably through the circular opening **18** in the end wall of piston **16**. The cylindrical member **30** itself has an end shoulder **38** which contains a circular opening **40**, the latter communicating with a bore **42** extending to the opposite end of said member **30**. The bore **42** contains internal threading **44**.

The drive shaft **32** extends slidably and rotatably through the end wall opening **40** of the cylindrical member **30**, and has an integral terminal extension **46** of enlarged diameter which is located within the threaded bore **42** of said cylindrical member. This terminal extension **46** carries external threading **48** sized to mesh accurately with the internal threading **44** of bore **42**.

The free end of the drive shaft **32** has an integral terminal portion **50** of square or other non-circular configuration which is used to mount a head-piece **52**. The head-piece **52** is circular, and has a central aperture **54** of non-circular shape, which is sized to receive the non-circular terminal portion **50** of the drive shaft **32**, such that the head-piece **52** is keyed to the end of said drive shaft **32** and the two members turn in unison. On its outer face, the head-piece **52** has a kerf **56** adapted to receive the blade of a screw driver or similar tool. The head-piece **52** also has a circumferential flange **58** which is employed in mounting said head piece.

The drive shaft **32** is supported by an end wall **62** which closes off the front end of the hollow condenser body **10**. The end wall **62** is of the same elliptical shape as the interior of the condenser body and is sized to be fitted within its front end and secured by soldering to a

silver band 84 to complete the body assembly. The end wall 62 has an offset peripheral flange 64 which abuts the end surface of the condenser body 10, preventing the end wall 62 from moving further into the condenser body interior.

The end wall 62 also has a central circular opening 65 which is sized to receive the drive shaft 32 snugly but rotatably, and also has on its outer surface a circular recess 60 which is sized to receive the circumferential flange 58 of the head-piece 62. The end mounting assembly also includes a cover plate 66 of the same size and shape as the end wall 62 and its peripheral flange 64, the cover plate 66 having a central circular aperture 67 sized to receive the body of head-piece 52, but of smaller diameter than the head-piece flange 58.

In assembling the condenser, the drive shaft threaded extension 46 is screwed into the threaded bore 42 of the intermediate cylindrical member 30, and the threaded end portion of the latter is in turn screwed into the threaded bore 20 of piston 16, whereby to couple the piston 16, cylindrical member 30 and drive shaft 32. The piston 16 is then slidably inserted into the through bore 14 of the condenser body 10, with the free end of drive shaft 32 projecting out of the condenser body. The end wall 62 is then mounted on the condenser body 10 as previously described, with the drive shaft 32 extending through the end wall opening 65, and the head piece 52 is attached to the drive shaft terminal portion 50. The cover plate 66 is then placed in position covering over the circumferential flange 58 of head piece 52, and with the main body of head piece 52 extending through the circular central aperture 67 of cover plate 66.

The cover plate 66 is secured in mounted position by a pair of screws 68 (shown in FIG. 5) which extend into the end wall flange 64. These screws 68, when tightened, cause the cover plate to frictionally engage the head piece flange 58 and therefore slightly bind the headpiece 52. This binding creates a drag on the headpiece 52 which is transmitted to the attached drive shaft 32, and tends to prevent undesired or accidental rotation of the drive shaft 32.

In order to prevent backlash and slippage as the condenser is adjusted, and thereby provide more accurate tuning control of the condenser, keyhole-hole slots 70 and 72 are cut into the enlarged end portions 46 and 34 of the drive shaft 32, and the intermediate cylindrical member 30, respectively. Set screws 74 and 76 are mounted in the end faces of the respective terminal portions 46 and 34, and extend into the respective slots 70 and 72. When the set screws 74 and 76 are tightened or turned inwardly, their ends engage the opposite wall surfaces of the respective slots and the screws exert a spreading force on the slots 70 and 72. This spreading force presses the external threads 36, 48 slightly out of alignment with the respective meshing internal threads 22, 44 and thus creates a drag on the screw threading of the piston, the intermediate cylinder and the drive shaft. Since the set screws 74 and 76 are threaded into the rear end surfaces of the drive shaft 32 and cylinder 30, which surfaces face the open end of the condenser body 10, the screws are accessible for adjustment by insertion of a screw driver or the like through the condenser open end. In order to assure the smoothest and most efficient adjustment of the condenser, one of the screws 74 or 76 should be tightened slightly more than the other, in a manner which will be presently described in detail.

The piston or movable electrode 16 is made of the electrically-conductive material, as is the intermediate cylindrical member 30, the drive shaft 32, and the end wall 62. It is desirable that this conductive material should have a low coefficient of thermal expansion which is similar to that of the dielectric material from which the hollow body 10 is fabricated. It has ben found that "Invar," an iron-nickel alloy is quite similar in expansion characteristics to the body material of the condenser, and accordingly its use is preferred. The head-piece 52 and the cover plate 66 may be made of insulating material.

A terminal lug 80 is affixed to the fixed electrode 12 on the outer surface of the condenser body 10. A second terminal lug 82 is affixed to a conductive metal band 84 which is in turn affixed around the front end of the condenser body 10. The band 84 makes contact with the flange 64 of the end wall 62.

The terminal lugs 80 and 82 are adapted to be connected in the usual manner within a circuit, as for example, to circuit lead wires. The fixed electrode 12 is energized by the lug 80. The movable electrode or piston 16 is energized by lug 82 through the band 84, the end wall 62, the drive shaft 32, and the intermediate cylindrical member 30. In the fully extended position of piston 16, shown in FIG. 2, said piston is in registry with the fixed electrode 12 and the unit is in condition for maximum capacitance. In the fully-retracted position of FIG. 3, the piston 16 is completely spaced from the fixed electrode 12, and this position represents the minimum capacitance of the unit.

In describing the operation of the condenser, it will be assumed that the condenser parts are in the extended position of FIG. 2, representing the maximum capacitance of the unit. In order to adjust the condenser, the user inserts a screw driver or similar tool in the kerf 56 of head piece 52 and rotates the same. As the head-piece 52 is turned, the drive shaft 32 turns in unison.

At this point, it should be mentioned that the set screw 74 is tightened to a greater degree than the screw 76, so as to impart a greater frictional tension on the drive shaft threading 48 and cylinder internal threading 44 than between the cylinder external threading 36 and the piston threading 22. Consequently, as the shaft 32 is rotated, the intermediate cylinder 30 rotates with it, and its external threading 36 turns within the internal piston threading 22. The piston 16, because of its elliptical shape, cannot rotate, and this screw action therefore moves the piston longitudinally, the piston sliding through the hollow body 10 toward the right, as viewed in FIG. 2, and out of registry with the fixed electrode 12, decreasing the capacitance of the unit.

As the drive shaft 32 continues to rotate, the piston 16 slides through the hollow condenser body relative to the longitudinally immovable intermediate member 30 and drive shaft 32 until its rear edge comes into registry with the rear edge of the enlarged end portion 34 of intermediate member 30. At this point a stop plate 88 affixed to the rear edge of the piston as by a screw 90, engages the rear edge of the intermediate member end portion 34 and stops further longitudnial movement of the piston 16 relative to the intermediate member 30. The intermediate member 30 thus becomes rigidly coupled to the piston 16 and can no longer rotate. Continued turning of the drive shaft 32 now causes meshing of its external threading 48 with the internal threading 44 of the stationary intermediate member 30, and the latter is thus moved longitudinally to the right, as viewed in FIG. 2. As the intermediate member moves longitudinally, it carries with it the piston 16 until the latter reached its fully retracted position of FIG. 3, in which it is wholly out of registry with the fixed electrode 12, and the unit is at its minimum capacitance.

The fully retracted position is determined by engagement of the end wall 19 of piston 16 with the fixed end wall 62. The piston 16 can no longer move further to the right, and the sets of screw threading bind to prevent further rotation of the drive shaft 32 in the same direction.

In moving the piston 16 back toward its extended position, the drive shaft 32 is turned in the opposite direction. Because of the difference in tension between screws 74 and 76, the intermediate cylinder 30 at first turns with the drive shaft 32, advancing the piston 16 longitudinally toward the left until its end wall bordering the circular

opening **18** engages the enlarged end portion **34** of the intermediate member **30**. The intermediate member **30** is now restrained from rotating, and the drive shaft **32** turns within said intermediate member, moving the latter to the left until the piston **16** is carried to its fully-extended position. In this position, the enlarged terminal extension **46** of said drive shaft **32** engages the end shoulder **38** of the intermediate cylinder **30**, halting further outward movement.

It should be understood that the relative tightness of the screws **74**, **76** may be reversed, in which case the intermediate member **30** will first travel longitudinally and then the piston **16**.

It will be observed that the telescoping action of the piston **16**, intermediate cylinder **30**, and drive shaft **32**, with the two sets of screw threads, permits the use of very fine threading over large total distances, and consequently achieves very fine tuning by requiring a high degree of rotation of the drive shaft **32** to achieve a relatively short longitudinal movement of the piston. At the same time the drive shaft **32** is always longitudinally immovable and never projects from the exterior of the condenser body as is usual in conventional trimmers. Thus, the over-all size of the unit is considerably reduced.

As was previously explained, the elliptical shape of the piston **16** and of the hollow body **10** prevents the piston from turning during adjustment even though the piston may have a free fit in the bore of said hollow body and therefore need not require tight tolerances. This provides for finer and more accurate adjustment of capacitance. In addition, the elliptical shape of these parts provides for greater electrode area than would be afforded by a circular shape with a consequent increase in capacity.

With the construction shown herein, the unit may be easily designed to produce selected modifications in capacitance adjustment. For example, the sides **10***a* of the elliptical body **10**, corresponding to the short radius thereof, may be made of lesser thickness than the other portions of the condenser body, as shown in FIG. 4. In this event, the fixed electrode **12**, instead of being made in the form of a continuous elliptical band, may be made in two separated segments located on these thinner sides **10***a* and arranged in tandem. This will produce ultra-fine variations in capacitance.

It is to be understood that while the invention has been described herein in connection with a trimmer capacitor, it is contemplated that the adjustment means may be equally applied to all types of adjustable reactance units having movable electrodes of the plunger type.

A latitude of modification, change and substitution is intended in the foregoing disclosure, and in some instances some features of the invention will be employed without a corresponding use of other features. Accordingly, it is appropriate that the appended claims be construed broadly and in a manner consistent with the spirit and scope of the invention.

What I claim is:

1. A variable electrical reactance unit comprising a hollow body having a longitudinal bore of elliptical cross-section, a piston of elliptical cross-section contained in said housing for sliding and non-rotatable movement therein, and drive means for moving the piston longitudinally in said housing, said drive means comprising an internally threaded cylindrical bore in said piston, an intermediate member having external threading meshing with the internally threaded piston bore for telescoping movement of said intermediate member with said piston when said intermediate member is rotated, said intermediate member also having an internally threaded cylindrical bore, a drive shaft journalled in said hollow body and extending longitudinally thereof, external threading on said drive shaft meshing with the internally threaded bore of said intermediate member for telescoping movement of said drive shaft with said intermediate member when the drive shaft is rotated and means for rotating said drive shaft from the exterior of said hollow body.

2. A variable electrical reactance unit according to claim 1 which also includes stop means for limiting longitudinal and turning movement of said intermediate member relative to said drive shaft and relative to said piston.

3. A variable electrical reactance unit according to claim 1 in which said intermediate member and drive shaft each have friction means for adjustably varying the friction between the external threading on the intermediate member and the internally threaded piston bore and between the external threading on the drive shaft and the internally threaded intermediate member bore respectively.

4. A variable electrical reactance unit according to claim 3 in which said friction means comprises a transverse slot in said intermediate member and drive shaft extending through the external threading thereof, and a respective screw engaging each of said slots and adapted to spread apart the respective threading through which said slot extends.

5. A variable electrical reactance unit comprising a hollow body having a longitudinal bore, a piston slidably contained in said housing, drive means for moving the piston longitudinally in said housing, said drive means comprising an internally threaded bore in said piston, an intermediate member having external threading meshing with the internally threaded piston bore, said intermediate member also having an internally threaded bore, a drive shaft journalled in said hollow body and extending longitudinally thereof, external threading on said drive shaft meshing with the internally threaded bore of said intermediate member and means for rotating said drive shaft from the exterior of said hollow body, and adjustment means for selectively varying the tension of the external threading on the intermediate member and drive shaft, said adjustment means comprising a respective transverse slot in said intermediate member and drive shaft extending through the external threading thereof, respective set screws threadedly mounted in said intermediate member and drive shaft and engaging a wall of the slot thereof, each screw being selectively turnable to spread the corresponding slot and upset the threading adjacent thereto.

6. A trimmer capacitor comprising a hollow body member of dielectric material having a longitudinal bore of elliptical cross-section, a fixed electrode on the outer surface of said body member, a movable electrode of elliptical cross-section slidable in said longitudinal bore, and drive means for said movable electrode, said drive means comprising a threaded bore in said movable electrode, an intermediate member having external threading meshing with said threaded bore for telescoping of said intermediate member within said piston bore upon rotation of said intermediate member relative to said piston, a threaded bore in said intermediate member, a drive shaft journalled in said body member and extending longitudinally thereof, external threading on said drive shaft engaging the threaded bore of said intermediate member for telescoping of said drive shaft and intermediate member upon rotation of said drive shaft relative to said intermediate member, stop means for halting movement of the intermediate member relative to the piston when the intermediate member is telescoped therewith, stop means for halting movement of the drive shaft relative to the intermediate member when the latter members are telescoped, and means for adjusting the tension of the threading between the movable parts for selectively determining the order of relative rotation of the parts upon turning movement of the drive shaft.

7. A trimmer capacitor according to claim 6 in which said stop means comprises a stop plate on said piston engageable with the intermediate member when the latter is telescoped with said piston, and an end wall on said body member positioned to be engaged by said cylin-

drical member when the latter is telescoped with the drive shaft.

8. A trimmer capacitor according to claim 6 which also includes a head piece rotatably mounted on the body member and accessible from the exterior thereof, and means rigidly coupling the drive shaft with said head piece for rotation of the drive shaft when the head piece is rotated.

9. A trimmer capacitor according to claim 6 in which said adjusting means comprises a respective transverse slot in said intermediate member and drive shaft extending through the external threading thereof, and a respective screw engaging a wall of each slot and adapted to spread the slot apart and upset the meshing engagement of the threading through which the slot extends.

10. A variable electrical reactance unit comprising a hollow body having a longitudinal bore, a piston slidably contained in said bore, an intermediate member threadedly engaging said piston for rotation of said intermediate member to produce longitudinal telescoping movement of said piston, a drive shaft journalled in said hollow body and extending longitudinally thereof, said drive shaft threadedly engaging said intermediate member, and means for rotating said drive shaft from the exterior of said hollow body to produce longitudinal telescoping movement of said intermediate member, said intermediate member and said drive shaft each having friction means for adjustably varying the friction between said intermediate member and said hollow body and between said drive shaft and said intermediate member.

11. A variable electrical reactance unit comprising a hollow body having a longitudinal bore, a piston slidably contained in said bore, an intermediate member threadedly engaging said piston for rotation of said intermediate member to produce longitudinal telescoping movement of said piston, a drive shaft journalled in said hollow body and extending longitudinally thereof, said drive shaft threadedly engaging said intermediate member, and means for rotating said drive shaft from the exterior of said hollow body to produce longitudinal telescoping movement of said intermediate member, said intermediate member and said drive shaft each having friction means for adjustably varying the friction between said intermediate member and said hollow body and between said drive shaft and said intermediate member, said intermediate member and said drive shaft being externally threaded, said friction means comprising a transverse slot in each of said intermediate members and said drive shaft extending through the external threading thereof, and respective screws engaging each transverse slot and adapted to spread apart the external threading through which the respective slot extends.

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