

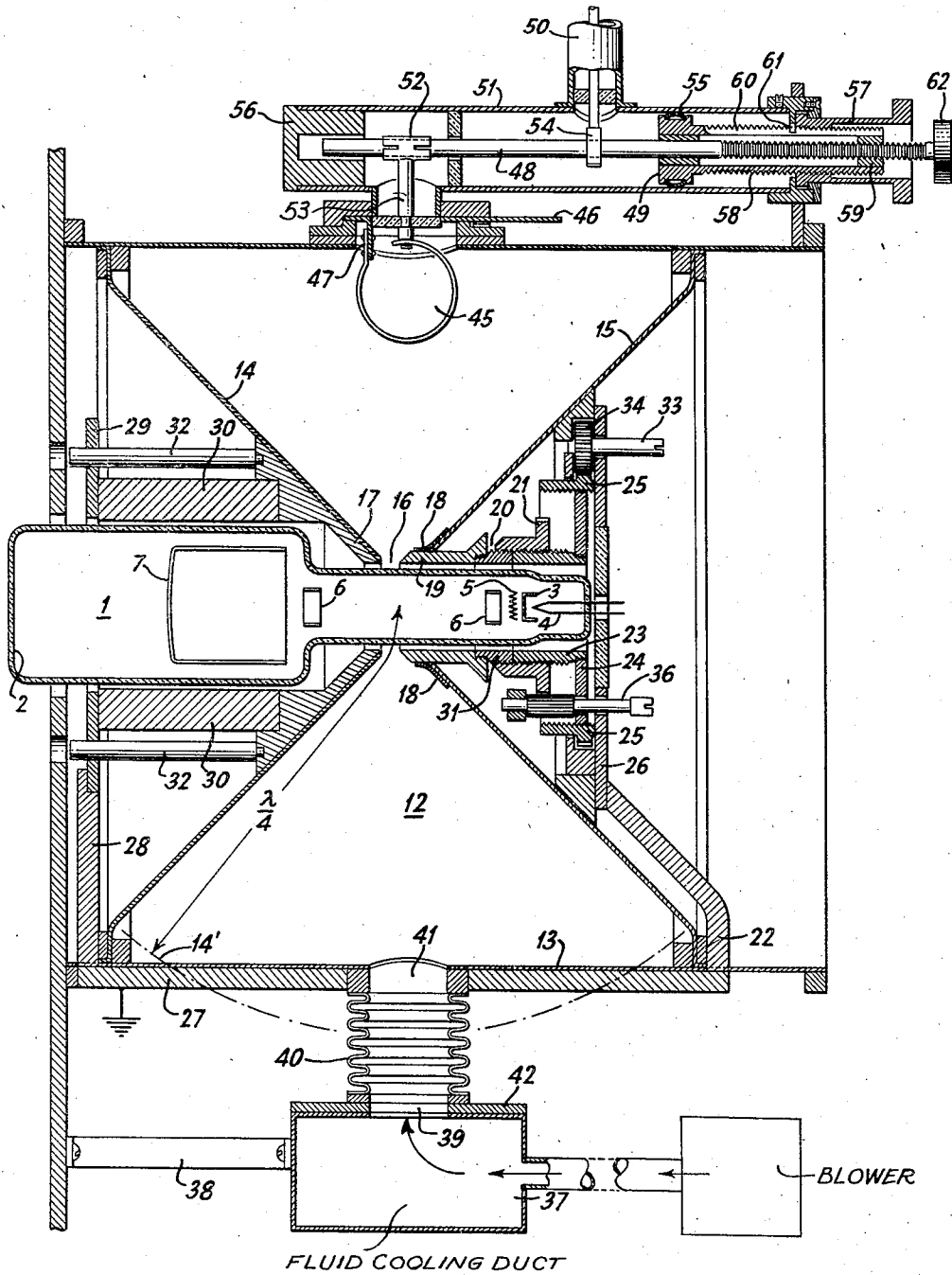
**July 16, 1946.**

**O. E. DOW**

**2,404,279**

## ULTRA SHORT WAVE SYSTEM

Filed Aug. 7, 1941



INVENTOR  
ORVILLE E. DOW  
BY *H. Hoover*  
ATTORNEY

## UNITED STATES PATENT OFFICE

2,404,279

## ULTRA SHORT WAVE SYSTEM

Orville E. Dow, Port Jefferson, N. Y., assignor to  
Radio Corporation of America, a corporation of  
Delaware

Application August 7, 1941, Serial No. 405,737

20 Claims. (Cl. 315—5)

1

This invention relates to ultra short wave apparatus for use particularly with electron discharge device circuits.

One of the objects of the present invention is to provide a simplified and efficient electro-mechanical construction for a cavity resonator, whose resonant frequency is readily adjustable, for use at ultra short waves.

Another object of the present invention is to provide improvements in the method of and means for applying a magnetic field to the cavity resonator for focussing the electron beam passing through the interior of the electron discharge device.

A further object is to provide an improved coupling circuit for use between the cavity resonator and a useful load, in which adjustments in damping and tuning or in tuning alone can be easily and accurately made.

A further object is to provide a cooling system for the resonator and associated electron discharge device, wherein the linkage between the high frequency apparatus and the blower duct is electrically shielded.

Numerous features of the present invention reside in the novel mechanical constructions employed (1) in the coupling circuit, whereby both the tuning and the damping can be changed independently; (2) in the apparatus employed for controlling the amount of the magnetomotive force required for focussing the electron beam; (3) in the adjusting means for varying the resonant frequency of the resonator by adjusting the length of its gap; and (4) in the flexible metallic bellows arrangement for simplifying the assembly of the resonator and the air duct carrying cooling fluid from the blower to the resonator.

Other objects and features will appear from a reading of the following description which is accompanied by a drawing whose single figure illustrates, in section, a preferred form of ultra short wave electron discharge circuit embodying the principles of the invention. Since the invention is primarily concerned with improvements in the mechanical construction, the vacuum tube apparatus is merely shown in outline.

Referring to the drawing in more detail, there is shown an electron discharge device 1, comprising a vacuum tube structure consisting of an evacuated glass envelope 2 containing therein a cathode 3, the heater 4, a modulating grid 5, ring-like accelerator electrodes 6, and a collector electrode 7, the latter containing therein a suitable suppressor electrode, not shown. This type of electron discharge device is now well known in the art and is not being claimed per se, the showing being given merely to illustrate how it fits into the resonator structure and associated apparatus constituting the invention. For a more detailed description of the electron discharge device with

2

resonators and coupling circuits generally equivalent to those shown in the drawing, reference is made to copending applications Serial Nos. 296,045 and 346,106, respectively filed September 22, 1939, by Fred H. Kroger, and July 18, 1940, by Orville E. Dow.

Surrounding the exterior of the glass envelope 2 in symmetrical fashion, and located intermediate the two accelerator electrodes 6, there is provided the high Q, low-loss tank circuit 12 in the form of a cavity resonator constituted by a copper cylinder 13 whose ends are closed by truncated cones made of sheet copper 14 and 15. The dimension of the tank support, as measured from the center of the glass envelope 2 toward the arc of the sector shown in dotted lines at 14', is approximately one-quarter of the length of the communication wave corresponding to the resonant frequency. It should be noted that the shape of the resonator 12 departs somewhat from that shown in the copending applications, supra, mainly in the lengthening of the resonator at the extreme edges and in the shortening of the resonator at the center due mainly to the provision of the cylindrical element 13. This departure in shape of the resonator from a true arc sector does not deleteriously affect the operation of the resonator. In order to vary the resonant frequency of the cavity resonator 12 to a limited degree, there is provided an adjustable gap 16, one side of which is formed by a copper plated iron sleeve 19, movable in a manner described hereinafter, and the other side of which is formed by an iron pole piece 17 as a consequence of which there is obtained a variation of the capacity between sides 19 and 17 of the gap. Sleeve 19 is made to move in an axial direction and makes sliding contact with beryllium copper springs 18, which are soldered to copper side 15 of the resonator. Sleeve 19 is preferably copper plated in order to provide low loss and a good electrical connection between elements 15 and 19.

For focussing the electron beam there are provided a pair of magnetic lenses in series relation constituted by magnetic gaps 15 and 20 formed, respectively, by the spaced iron sleeves 17 and 19 and spaced iron sleeves 19 and 21, all of which surround the glass envelope 1 and are serially arranged with respect to an iron magnetic path. This magnetic path includes an iron yoke 22 which is placed adjacent to the sides of one sector of the tank circuit 12, the complete circuit of which includes elements 17, 19, 21, 23, 24, 25, 26, 22, 27, 23, 29 and ring-like permanent magnet 30. Although elements 23, 27 and 22 are preferably constituted by a single iron yoke about one-quarter of an inch thick, they may, if desired, be formed of separate elements, as shown. The ring-like permanent magnet 30 is preferably made

of Alnico material and is held in fixed position by the iron pole pieces 17 and 29. The magnetic flux will obviously flow through the path mentioned above and across the magnetic gaps 18 and 20. The threaded ring or sleeve 31 is made of brass and is integrally connected to the threaded ring 23. Because ring 31 is made of brass which has the same magnetic permeability as air, there is a magnetic gap 20 provided between elements 19 and 21. In order to adjust the effective magnetomotive force of the permanent magnet 30, there are provided a plurality of removable iron pins 32 suitably spaced, preferably symmetrically positioned around the magnet, so as to short-circuit a desired portion of the flux produced by the magnet. These pins 32, it will be noted, bridge the pole piece 17 and the iron support 29 for the magnet.

Adjustment of the length of gap 16 is accomplished by rotation of the shaft 33. By rotating shaft 33 which connects to pinion 34, the ring gear 25 which is threaded to engage 34 will also rotate. Since ring gear 25 is internally threaded, it engages the threads on iron disc 24, and it will be apparent that movement will be imparted to the iron disc 24. The latter is kept from rotating by means of a pair of pins 36, only one of which is shown in the drawing. Movement of the iron disc 24, however, will cause axial movement of the integrally connected iron sleeve 23 and brass sleeve 31. Since brass sleeve 31 is linked by threads to iron sleeve 19, it will be evident that axial movement of 23 and 31, caused by movement of disc 24, will also cause axial movement of the copper plated iron sleeve 19 and thus produce a change in the width of the gap 16 with a consequent change in the resonant frequency of the cavity resonator 12. One of the pins 36 which prevents rotation of the iron disc 24 has the additional function of rotating cylindrical ring gear 21 for varying the length of the magnetic gap 20 between elements 19 and 21. Ring gear 21 is internally threaded and rides on the threads of sleeves 23 and 31. An adjustment of the gap 20 changes the strength of the magnetic field in the plane of this gap. Since gap 16 is in series with gap 20, the magnetic field in the plane of gap 16 will also be changed. The magnitude of the magnetic field at both gaps can be readjusted by increasing or decreasing the number of shunts 32 across the magnet 30. Thus, by adjusting gap 20 and shunts 32 the proper magnetic field can be obtained at both gaps.

In order to cool the vacuum tube 1, there is provided a metallic rectangular blower duct 37 which has cooling air forced therethrough from a blower. This blower duct is mounted on one or more suitable metallic studs 38 and communicates by means of aperture 39 and metal bellows 40 with the interior of the cavity resonator 12 through another aperture 41. The blower thus produces a forced ventilation which causes air to flow through duct 37, through the bellows 40, through aperture 41 into the interior of resonator 12 and around the envelope of vacuum tube 1 at the location of the gap 16. The air then flows around the vacuum tube envelope 2 toward both the electron collector end and the grid end. Bellows 40 is made of a metallic material to prevent radiation of radio frequency energy from the resonator 12. This bellows is rigidly fastened to the resonator 12 at the cylinder 13 and acts as a flexible link to insure a tight connection from the resonator to the duct 37. It should be noted that the end of the bellows 40 which contacts the

duct 37 is provided with a sheet of metal 42 affixed thereto. Since the blower duct 37 is rigidly fastened by means of stud 38 to the cabinet or panel of the equipment it is a relatively simple matter to position the resonator 12 in its desired location and to flex the bellows 40 in such manner that the aperture in metallic sheet 42 registers with the aperture 39 in the duct 37. In this way a single duct 37 provided with several spaced apertures 39 may serve to supply forced ventilation to a plurality of spaced resonators 12 suitably located along the length of the duct opposite the spaced apertures 39.

In order to abstract energy from the cavity resonator 12 there is provided the output coupling coil or loop 45 which can be rotated 90° by means of lever 46 to vary the coupling between the resonator and its output coil support from maximum to a minimum. The output circuit is electrically one-half wavelength long at the operating frequency as measured from the fixed ground point 47 around the loop 45 along conductor 48 to the plunger disc 49. This output circuit may be a band pass coupling circuit and is very generally the equivalent to that shown in copending application Serial No. 346,106, supra, except for certain refinements which are described hereinafter. The coil 45 serves to couple the tank circuit 12 to a suitable load or utilization circuit which may comprise an antenna connected to the output line 50. The coupling circuit includes a coaxial line comprising an inner conductor 48 and an outer conductor 51, the inner conductor of which is electrically connected through a slider coupling link 52 to a metallic conductor 53 which, in turn, connects with one end of the loop 45. The output line 50 is connected electrically to another point on the inner conductor 48 by means of a metallic spring clip 54. The plunger 49 serves to short circuit the conductors 48 and 51 in order to change the damping of the coupling circuit. In order to provide good electrical contact between the plunger 49 and the inner surface of the conductor 51 of the coaxial line, there is employed a flexible metallic ribbon or strip of sheet metal 55 which has transverse cuts therein so formed as to produce a multiplicity of resiliently bulging contact areas with the circular areas engaging the conductor 51. In this way there is obtained both good electrical contact at numerous points between the inner surface of the conductor 51 and the plunger 49 and also very smooth sliding or wiping action when it is desired to move the plunger. For a more detailed description of this type of sliding action, reference is made to United States Patent No. 2,280,728, granted April 21, 1942, to A. Streib.

It should be noted that the free end of the inner conductor 48 of the output coupling circuit forms part of a concentric conductor condenser, one electrode of which includes a metallic plug 56 electrically connected to the end of outer conductor 51. By moving conductor 48 in or out of the plug 56, I am able to vary the capacity between the end of conductor 48 and the plug 56 and thus tune the output circuit. In order to have movement of plunger 49 result in only a change in the damping of the circuit, means are provided to vary simultaneously both the plunger 49 and the condenser 56, 48. Thus the tuning change which would result in a movement of plunger 49 is balanced by a change in condenser 56, 48. For this purpose there is provided an internally threaded cylinder 57 which threadedly engages a hollow element 58 on its

5

exterior surface, the latter in turn threadedly engaging the inner conductor 48 at 59. One end of the hollow element 58 is fixedly attached to plunger 49 so that movement thereof will move the plunger and change the damping of the output coupling circuit. In order to prevent element 58 from rotating, there is provided a key way 60 which cooperates with a pin 61. By rotating cylinder 57, axial movement of the plunger 49 will ensue, and simultaneously therewith, also axial movement of the conductor 48, with a consequent change in the capacity of the concentric conductor condenser. However, since the capacity per unit length of the condenser 56, 48 is greater than of the line 51, 48, this would result in over correction for the tuning. Therefore, means are provided to rotate 57 and 62 together while still leaving them free to move axially with respect to each other. The pitch of thread 59 is finer than the pitch of the thread of 57. Thus, when 57 and 62 are rotated simultaneously, the axial movement of 48 is less than the axial movement of 49. Thus, for a particular ratio of inside diameters of 56 and 51 the proper differential between the thread of 57 and the thread 59 can be chosen. If the inside diameter of 56 is equals to the inside diameter of 51, rotation of 57 alone will result in the proper compensation of tuning when it is desired to change the damping. If it is desired merely to change the tuning of the output coupling circuit without changing the damping, this is done by rotating knurled knob 62 which varies the length of the inner conductor 48 within plug 56. The circuit 52, 53, 45, 47 will in general be a high impedance circuit.

It should be understood that the various features of the present invention can be utilized either alone or combined and that the vacuum tube 1 may be used in an ultra short wave system either as an oscillator, an amplifier, frequency converter, or a detector. Such circuits embodying the principles of the present invention have been used with high efficiency at frequencies above 300 megacycles, particularly around 450 megacycles, though not limited thereto. The electrical connections necessary to complete the circuits for the vacuum tube have not been shown because they may follow any of the teachings set forth in the copending applications supra, the invention not being limited thereto.

What is claimed is:

1. A hollow resonator having apertures in both sides thereof forming a gap, an electron discharge device having an envelope extending across said gap, a cathode and a collector electrode in said envelope at opposite sides of said gap for causing an electron stream to traverse said gap, spaced adjustable magnetic elements adjacent said sides of said resonator and having a magnetic gap registering with the gap of said resonator for providing a magnetic lens at said resonator gap and for varying the width of the resonator gap, and movable means for varying the distance between said spaced elements.

2. A hollow resonator having apertures in both sides thereof forming a gap, means for causing an electron stream to traverse said gap, spaced adjustable magnetic elements adjacent said sides of said resonator and having a magnetic gap registering with the gap of said resonator for providing a magnetic lens at said resonator gap and for varying the width of the resonator gap, and movable means for varying the distance between said spaced elements for varying the width of

6

said resonator gap without moving any part of said resonator.

3. A hollow resonator having apertures in both sides thereof forming a gap, means for causing an electron stream to traverse said gap, magnetic means adjacent both sides of said resonator and having a gap registering with the gap of said resonator for providing a magnetic lens at said gap, a resilient metallic element attached to one side of said resonator and contacting said magnetic means at said same side, and movable means for varying the width of the gap of said magnetic means.

4. A hollow resonator having a gap along the axis thereof, magnetic means having a magnetic gap registering with the gap of said resonator for providing a magnetic lens thereat and also having a magnetic gap externally of said resonator to provide another magnetic lens, means for causing an electron stream to traverse the gaps of both lenses in succession, and gears threadedly engaging said magnetic means for varying the width of that magnetic gap registering with the gap of said resonator for varying the tuning of said resonator without moving any part of said resonator.

5. A hollow resonator having apertures in both sides thereof forming a gap, means for causing an electron stream to traverse said gap, spaced adjustable magnetic elements adjacent said sides of said resonator and having a magnetic gap registering with the gap of said resonator for providing a magnetic lens at said resonator gap and for varying the width of the resonator gap, and movable means for varying the distance between said spaced elements for varying the width of said resonator gap without moving any part of said resonator, said last means including a threaded element linked to one of said magnetic elements.

6. An electron discharge device having within an envelope a cathode for projecting a beam of electrons and a collector electrode for receiving said beam, three spaced hollow members of magnetic material adjacent said envelope and surrounding the path of electrons and having positions located between said cathode and collector electrode, two adjacent members of said three being adjustable along the length of said beam, said spaced members providing a pair of magnetic gaps for focussing said beam, and gears threadedly engaging two of said members of magnetic material for varying the distances between any two of said three members.

7. A hollow resonator having apertures in both sides thereof forming a gap, means for causing an electron stream to traverse said gap, spaced adjustable magnetic elements adjacent both sides of said resonator gap and having a gap registering with the gap of said resonator for providing a magnetic lens at said resonator gap, a permanent magnet adjacent said magnetic elements, and magnetic means shunting said magnet for varying the effective amount of magnetomotive force produced by said permanent magnet.

8. A hollow resonator having apertures in both sides thereof forming a gap, means for causing an electron stream to traverse said gap, spaced magnetic elements adjacent both sides of said resonator gap and having a gap registering with the gap of said resonator for providing a magnetic lens at said resonator gap, a permanent magnet adjacent said magnetic elements, and a plurality of removable magnetic pins bridging said magnet

for short-circuiting a desired portion of the flux produced by said magnet.

9. A hollow resonator having apertures in both sides thereof forming a gap, means for causing an electron stream to traverse said gap, spaced magnetic elements adjacent both sides of said resonator gap and having a gap registering with the gap of said resonator for providing a magnetic lens at said resonator gap, adjustable means for varying the distance between said magnetic elements without moving any part of said resonator, a permanent magnet adjacent said magnetic elements, and means in shunt to said magnet for varying the effective amount of magnetomotive force produced by said permanent magnet.

10. A hollow resonator having apertures in both sides thereof forming a gap, an electron discharge device having an envelope extending across said gap, and means for cooling said device comprising a flexible hollow metallic link affixed at one end to and communicating with the interior of said resonator, a metallic sheet affixed to the other end of said link, said sheet having an aperture, an air duct having an aperture therein, and a blower connected to said air duct, the apertures of said metallic sheet and said duct registering with the aperture of said flexible link, whereby air from said blower is forced into the interior of said resonator and flows around the envelope of said device at the location of said gap.

11. An electron discharge device having within an envelope a cathode for projecting a beam of electrons and an electron collector, a hollow space resonator having a gap surrounding a portion of said envelope at a location between said cathode and collector, said resonator also having a fluid inlet port remote from said gap and leading directly into said resonator, and means connected to said port for forcing cooling fluid directly into said resonator through said port.

12. An electron discharge device having a cavity resonator in circuit therewith, an energy transfer circuit coupled to said cavity resonator, said transfer circuit comprising a coaxial line having its inner conductor coupled to said resonator by means of a loop entering the resonator through an aperture, said inner conductor being inductively coupled to said resonator in said interior by virtue of said loop, means for rotating said loop for varying the coupling between the resonator and said transfer circuit, said coaxial line having an opening in the outer conductor externally of said resonator, and a section of another coaxial line having its inner conductor coupled at one end to the inner conductor of said transfer circuit through said opening and its outer conductor at said same end coupled to the outer conductor of said transfer circuit, and slidable means within the coaxial line of said transfer circuit for adjusting the effective length of the inner conductor of said transfer circuit as measured from said slidable means to the junction point of the inner conductors of said coaxial lines.

13. The combination with a hollow resonator of a coupling circuit comprising a rotatable loop located in the interior of said resonator and conductors forming a coaxial line connected to said loop, and tuning and damping means linked to the conductors of said line.

14. An electron discharge device having a cavity resonator in circuit therewith, an energy transfer circuit coupled to said cavity resonator,

said transfer circuit comprising a coaxial line having its inner conductor coupled to said resonator by means of a loop entering the resonator through an aperture, said inner conductor being inductively coupled to said resonator in said interior by virtue of said loop, means for rotating said loop for varying the coupling between the resonator and said transfer circuit, said coaxial line having an opening in the outer conductor externally of said resonator, and a section of another coaxial line having its inner conductor coupled at one end to the inner conductor of said transfer circuit through said opening and its outer conductor at said same end coupled to the outer conductor of said transfer circuit, slidable means within the coaxial line of said transfer circuit for adjusting the effective length of a portion of said transfer circuit, and a tuning capacitor across one end of said transfer circuit, said capacitor being variable by movement of the inner conductor of the coaxial line of said transfer circuit.

15. Apparatus in accordance with claim 14, wherein means are provided mechanically linking the drive mechanism of said slidable means with the drive mechanism of said variable condenser.

16. The combination with a hollow resonator, of a band pass coupling circuit including a rotatable loop located in the interior of said resonator and a coaxial line connected to said loop, a short-circuiting bridge across said coaxial line, the length of said coupling circuit as measured from said bridge along said line and over the length of said loop to the remote end of said loop being electrically one-half wavelength at the mean operating frequency.

17. A hollow resonator having apertures in both sides thereof forming a gap, means for causing an electron stream to traverse said gap, spaced magnetic elements adjacent both sides of said gap and having a gap registering with the gap of said resonator for providing a magnetic lens at said gap, a permanent magnet connected to said magnetic elements, and a removable magnetic pin bridging said magnet for short-circuiting a desired portion of the flux produced by said magnet.

18. A hollow resonator, means including a cathode on one side of said resonator for projecting an electron stream through the interior of said resonator, spaced magnetic elements surrounding a portion of the path of travel of said stream and forming a gap, a permanent magnet connected to said magnetic elements, and a removable magnetic pin bridging said magnet for short-circuiting a desired portion of the flux produced by said magnet.

19. The combination with a hollow resonator of an energy coupling circuit comprising a rotatable loop located in the interior of said resonator and a stationary coaxial line connected to said loop, and adjustable means connected to the conductors of said line for varying an electrical characteristic of said line.

20. The combination with a hollow resonator, of an energy coupling circuit comprising a rotatable loop located in the interior of said resonator and a coaxial line connected to said loop, and tuning means in circuit with said line for varying the capacity across the conductors of said line.

ORVILLE E. DOW.