(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
26 July 2007 (26.07.2007)

PCT

(10) International Publication Number
WO 2007/085015 A2

(51) **International Patent Classification:**
B08B 3/00 **(2006.01)** *B08B 3/12* **(2006.01)**

(21) **International Application Number:**
PCT/US2007/060850

(22) International Filing Date: 22 January 2007 (22.01.2007)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:

60/760,820	20 January 2006 (20.0 1.2006)	US
60/837,965	16 August 2006 (16.08.2006)	US
60/850,930	11 October 2006 (11.10.2006)	US
60/885,978	22 January 2007 (22.0 1.2007)	US
11/625,556	22 January 2007 (22.0 1.2007)	US

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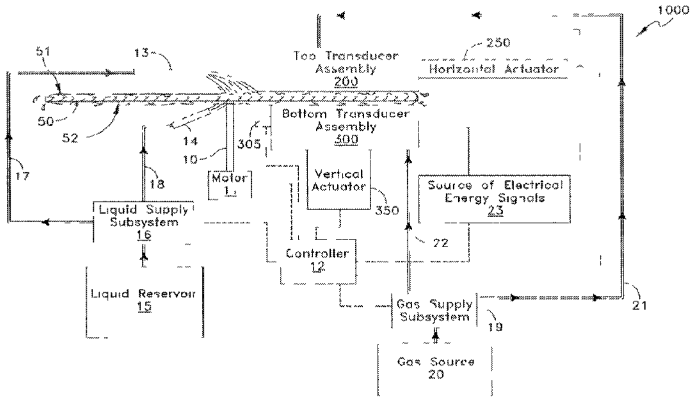
(81) **Designated States** *(unless otherwise indicated, for every kind of national protection available):* AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LV, LY, MA, MD, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, SV, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available):* ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasia n (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), Europea n (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, LV, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *without international search report and to be republished upon receipt of that report*

[Continued on next page]

(54) Title: ACOUSTIC ENERGY SYSTEM, METHOD AND APPARATUS FOR PROCESSING FLAT ARTICLES



(57) Abstract: A system, apparatus and method for processi ng this flat articles, such as semico nductor wafers, with acoustical energy. In a clea ning process, the inventive system, apparatus and method can remove particles from both sides of a wafer more efficie ntly and effectively in one aspect, the invention is a system for processi ng flat articles comprisi ng: a rotatable support for supporti ng a flat article; a first dispe nser for applyi ng liquid to a first surface of a flat article on the rotatable support; a seco nd dispe nser for applyi ng liquid to a seco nd surface of a flat article on the rotatable support; a first tra nsducer assembly comprisi ng a first tra nsducer for generating acoustic energy and a first tra nsmitter acoustically coupled to the first tra nsducer, the first tra nsducer assembly positio ned so that whe n the first dispe nser applies liquid to the first surface of a flat article on the rotatable support, a first meniscus of liquid is formed betwee n a portio n of the first tra nsmitter and the first surface of the flat article; and a seco nd tra nsducer assembly comprisi ng a seco nd tra nsducer for generating acoustic energy and a seco nd tra nsmitter acoustically coupled to the seco nd tra nsducer, the seco nd tra nsducer assembly positio ned so that whe n the seco nd dispe nser applies liquid to the seco nd surface of the flat article on the rotatable support, a seco nd meniscus of liquid is formed betwee n a portio n of the seco nd tra nsmitter and the seco nd surface of the flat article.

WO 2007/085015 A2

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

.ACOUSTICClNERG Ÿ SYSTEM, MJ£TH0» 4N'D APPAHATUS...FOR PROCESSING FEAT ARTICLES-

€røss-IMer& αefi ŧøt Related Patent AppiieafioBs

fWMH] The preset patent application cMms ŧhp benetfit of United States Provisional.?ate» ἐ AppIieat ΚmS£rial No.. (50/760,820, filed January 20, 2006; united -.States Pioylsioiial Patent Application. Send No, 60/837,965., fifeMsgust 1-6, 2006 ;* IJmted States ProvMoifsalPateat Application Serid 'No. 6D/S5.0$_s$930 $_s$ filed October 1 1, 2006; -United .Statøs.'.Ftøvl;ssαaai Patent Application Serki.No. 60/885^7S; filed. January 22$_5$.2007; and United States. N*n-Prqyxskmaj Patent Application Serial Mo, ΪI/&2S,5S ό$_y$ ŧiled Ja&uatiy·22,.2Q07 $_s$ the en&tetleg of ytfïish afe hetrøfe}* ύtcorpprated-b.y rsfejrence.,

Mεsld.of ŧhte lavenliost

[0S>02j *Tfa& pfss* ύ*n* ï ihveation ·relates geαaraliy to ώe field of processing flat pli αes uiife ïή g acoustic ·enekgy; 'sxid sρeθiIï ά?lly ŧo isystetms;, methods *m* ά εppatstu$ εhst utilise acoustic energy.for cleaiimg Hat. articles, such as .sesibanductor wafes;;

Baekgroaad of # e Mve»tfoa

[δøOSj .Iu the ï *ve&d* of ^emiQondu ςtor .nia πufacturing, it has be.eh .r^eόgπized imiea ŧfee t beginning of ifeebdusttythatremoviitg psriicks ï *to.m* semiconductor wafers dtmtig ŧhe t laanafactøiag. process is &critical req ύirej ïietjt ŧó producting quality ptofitabie wafers. WMIe Many different systems- s nïhnetliøds have bse« .developed over the years- i α remove ppticles .fXoiïv sεaiko πaïïctorvvafe κ?, *m m* γ offlies ε systems; and aie&ods arø iuï desirabie because ŧhey t .damage the wafers- Thus >tlie removal of particles *ItQi* ά wafers, which isWferi jneasured in terms of ŧitie paniøle- removal efficlency:("PRB rt)$_f$ must be balanced against ŧhe amount of t damage caused to ŧhe kf4i$ by the deara ή g mefliod. *am* ϋ*ot* systsm.. It is tϋerefore desrøbb ἐ &ei δaniag. πnssthod Of system to be able to. ρ δk -particles fee from ŧhfe delkat ἐ t seniicoftductor wafer without .resulting in damage to ŧhe devitcest-on ŧhe *WS£QT* surfacte,

fï)OΘ4| Existing ŧectlinlques.fer ii-eemg ŧlve partitcles from the surface of a semiconductor-Wafer *utilize* a combinatioii of chemical and mechanical processes. One ŧypical eicïsumtg. chemistry nsø&i α the *sxt* is standard .clean i ("SCI"}, ΛvKieins a iiii?ε«re αfJUBsionka. hydroxide, B.v.drt)g«n-peroxide, and water. SGΪ oxidizes and etches *the* -surface of ŧhe wafer. t This etching process, known as άiidercutting $_s$ reduces ;&e physical-contact arcs of ŧhe wate.r t Si5rfsce to WMcB. ώe. particle isi)ovui<! tiius ŧaciHtating όatse of removal .Hόwsv& ï a piatksniieal proses is still .reqtiirscl to actually rέtHOVethe parfele ïjoffi. the-\vaic? surface.

[0005]

[0006]

into vibration

For example, increasing the

[0007]

method of particle removal in semiconductor wet process applications. A

[0008]

United States Pat. No. 6,998,327 ... 21, 2006, and ...

("Itzkowitz"),

("Verhaverbeke et al."), published December

PRB requirements

Application Publication 2006702782:53 ("Verfeaverbefcs ct-a!,") with/the transducer assemblty located adjacent the bhaeckside of the Ratfter.

fóøïl] Despite the adv^mesaieiitS *in mig\$~w* ϕ *rsy$pø^m* ıά *mQthoUB iøτ d&&pmg 'hüïk* sides of the wafer, therte..-still remams a need for singie~\vafer. systems that can ;ackievs t improved F31E with misSïtJsted'devie e dsjïjage, FurthemiotCi tlie, continuedt miniatiti-feation-of .dsviees.co.tttbues to render esisHøg cka&Ihg systems iti cϕ iable.cif .achieving ait acceptable balance between liïgh PRB and minimi^d device damage.

SUMMARY *m* XEE INVENTION

|($.i2.| *Ii is,* iiiersCore a« .object of .the pt^sentim^nitionlo provide si systesi, apparatus and method &t processing itatartidssv such as semicoackttor wafers, *vάih* aco ύstjcSJ-energy.

[00i3.| Anoïher object of *ih&* pxesent inventlo:n is to provide .a system, apparatus atjd method: for siπilJitaneously cleaning both surface!; of flat articles, suoh ss-semiconductor wafers, TOth acoustical energy.

100.14} Still another object of the pretsent indention is to provMs atsystem, apparatus. and method for δim«itaiiett αsiy cieajjing both $ïirfaee&.øf flat articles, such as .semko πιfectø w&ïfers; with ssoust ïbal energy thai improves PKE *&n ά(o τ vnta&es* damage tó:ώe-IM -aMcfe..t

[90.1 Sj Yδt .^otlser Qb|ect of the-pretsent invention is to ptoykia a-tsystem. apparatus aiid jaethodfor applying acoystlosl energy to ihe:btottom surface of a rotatmg flat strtacle.

|flθï (>|. A .fctlher oBjsct of Hie present Invention is to provid.e.a system, appataais-and metltod for sim αlt-aieøwsly cleasitig- bolh surface έ of *iht* articles, such as seπιifcdaliict ó? wafers, that t utilize acoissfic ^ 3ζrgy rs;fleeti θ5i;

[0OI7J *A* still Tijrite objee:t: óf te ptresent inveation is to proylde *úh* ϕ *pnτ&Xxii m d* metiiod Ite-ailows existing skgle-^^lsr cleaners to bte. retrofitted to ach.ietye..fmproved cleaning of both surfaces of tits wafer,

(ODIS] A yet further object of fee present iftveation is to provide a system, ap^ratus-and-method that achiev:es ih&røase'd ïiqώd .coup.Iiiag between a traSsdacei assemtbly .and the bpitQffi surfjsee of a.fïat sï& ïe.

increases the backside

without increasing damage to devices

[0023 j Itxγtt.6ûiot6er. esїïbb<iimsM the Inventtion can be a system ïbr processing fiat articles comprising: a rotatabl© support for support iag and lOiatissgkiktatlielejn. a substantially JiorizohtaiQAWiatiott^^ ransducer assembly comprising a transducer for generating acoustic energy, a ttaupiitter,ad ói}stica|Iyc;oupJed to the fitrsttransducert arid &ά&m suπutrxdmg a? least a portion c?fa..perimeter of fej jrrøSK ïïtter- so. as lαfarm ajiqiild r^it ïiβg ϕ amie.l hefcsroea the trantsmitter aad the dam;- M d ihεlta ïisducef a'SxSerøbly positioned so-that a portion of the trarssmitter -is adjacent s bσfckmï surface of a flat article oft the ïoiata&le .suppotrt. so tli&t wbea llqxήά.h applied to the botttom- surface of the flat artictle, a.metrise μs of lfcfidd iβ famsd between tfae.pprti óii of the tratnsmittter and tiiε bottomt surface of the Sat astick.t

.|pO24] .te still aii ót!jes"iÜa bødi.KJ8iit, tbe inventtion caabe a transducer assembly tor moantiag banisath a bottom -surføϕø. of a flat article oαmpm ïng: atr ϕ3$ducεt.fot.ge.i ïeratmg acoustic energy; a traπsrnitter acoustically coupled to úl&. Srst transdueef : tod a.d&m siurouadmgat. k aÜl « portloti of &pen metet.of the f ajfjtsrøïtter.s ó ai> fo.form a liquid itetamtag cliatmel bstwtxiithe second tratnsmitter and die- dam,

fCrøiSj ñ a ftttthei*-emb ρdiïnβot, fh$ myention ca« fee &laetjhcd of ma»«f^et tirihg ^ tg&^dueer assemikly comprising.: providing. a par-cylin ώ'tcal ^nsmitter-p ïate: bottdlagoae oj more trausdxicers to a coxu^x.ktierrsiirface of the itantsmitter piate; coanecting a housing !ú.-the transmitter to cretate aa assei ïibly having a substaiLtlally encipsed cavity in vάikh tlie ohe at mpreitansducets ais lάάlfcά; m i άicapsulating the assembly wπdi ïm inert tiODrreacέfvet plastic.

[ββ2έ] [a^>yet.tehtTanb^diji»«nt;ife&Jnv<^tS.c)fi can be.^ method of próccssmg a lk.i as.lick Comprising; a}siϕ pάftiπg a ilat article in s sτhstaiitially horizontal orientation within a.. gaseous- atmosphere, &s flat article imvmg a bottotfl sυήace and atop surface; b). mfetiiig é fiat arfick^ while mdntøi πing th<? subsk ïittially bo«Koa ml.orie.nmiioa; s) applying a "filπsiof HqIiId to thte totp sur&ce of the .flat ariide; d) applying, a δlm of liquid on the bottom sutrface ofthe flat article; e) applying acoustic energy to the top surface of the flat artbl&t.vïa a first transducet assembly comprising a iïrst transducer and a &st transmittert, a potlion of the Sr^t tra∞nύtter in coutaet with the Hhiem of -liquid on tlie top surfatce efthe .flat attlck; aMf) applying acoustic -enargy to thet botttom; surface of the fist artictle via sseco ∑d trmisducet assetabty cotaprising a second transdtucer and a second transmitter, a poriiqn.of the second ftfaÜsinitt δr In. eont^ έt with theiiim of Uqalά on.the bottom sur&« of the flat article;

DRAWING

Figure 4 is a transducer assembly

transducer assembly.

invention wherein the transducer assembly

e transducer assembly for the acoustic energy cleaning

[0039] I-lgαre-91s -v cross-«ectioosl.view of -the schematic representation of the traiisdt&er t t .&^επji% -arrange πieni of FIG, S along: the cross-sectierecut B-B of FÏGJ.

[HM(IJ Figure 10 is a.sdiematic representatioa of a m alternative ^ttapgemesii of thelopskfe t :!sa&$d«cer assembly relative to the btottotm-side transducer assøiïξMy for tile acoustic gsergty cieaiii-xg system. of FIO-, 2:,

fO041| Figure- V! Is a crδss-seciioaai viewififee Schtematic ÷rejJrέsBRMbii of fee &iier.mstive.- transducer assembly arrangement of FIG. I D along the cross~seetiot ι cut C-C βf HChS .

|W42] Figure I2 is;,sJ?Heroatk of ah. aeoiïstic energy oleaiiiag.-sj'sSeïxi uti!iisii3g a reJl ecth-s svefliijer according to ose embodh ïteftt of itepresent layeiitipn,

[0#43I F.tgarc I3- ia sciieojatk ofati acoisstb energy ck-δiii∑g system αtiÜzing a rd ï εciiYe: tiieiiiber according to tandteniatl^e embodiment of tbepreset ω mveπtion.

|0044| Ffeia"« 14 shoe's .€vealtett ïati^ ε-.embodjments of atraiisdacef asstemWy &at can also acta^axeflectiye jaember for use lathe acoustic energy clesiuBg system of FJG. .12-

DES ς RïFTIQN OF THE INVENTION.

[Ü&45] Referring first to FtIG. I, &schematic αf ari schistic ..energy cleasing system *M W {hg*ï *ύ m* ï *lcr&Bi* ï *zeά* to as "ckajtimg system 1000") is illuslpted accordhigtp one embodiment of the preseMiftventlQ α Fox es,se *of* disct^sioii &e.iïπ:eπtxve system and aistho«l$ *ofsM* ϕ -awiiigs. will Bs disc αsseii in reM αaio *ihαϕ sxύng* of semiconductor .wafers. However, the kwenti όn is not so Hmlted and can be utilized ï*ør m$γ.ύzύtzά* wet processing of any flat article;.

|ΘI4()| Hie cl&Knmg sj,Stsiiï 1000 geneMIy comprises a top transducter atissembly 200, bottom transducer ps^mbly 3S0 a».d a ïotatable ?;uppβtt 10 for su|sportis.ig..a sεiBlcoïiducfor ^afer 50 m a sύbstMtiai.ly boriEontal orie»tatk>xi- Preferably; tlie semicotnductor wafer 50 is-.supported so its. totp sαπfece 51 is thi?Λføvtice ύ *ih* of the wsier 50 while the bottoxs surface S2 Is tfafe.non- t dtndce.si.de. .Of coarse, the vvatfe catxbe supported so that Jtstop.stutface Sl is the non-device side ΛyMle &e bottom syriaee 52 is tlie. device side if desired.

|0047] -liiq jotatable support 10 is designed to contatct *&nd* engage only a perimeter of file substrate 50 *m* pprfom Üng its support femction. However, tiie :esáct dettails of the structure of the rpMafole .support: I S are not. limiting öf &e ρres β»t roventio ή and a wide variety of oiHer stϕ port strttδtva'δs can be. «sed r sueh as:eBueks s .supj3ort plates, dtc, :A4<litional \ while ills ptrf^^^sithat *th& support sttικtmt* . support aι d rotatq thessmicoBciuctpf wifer ib: a

may system the invention,o embodiments orie.iitatiorr,,m horizontal substantially be configured so t a b s atatinss, other supported Wifer semiconductor cleaning o t e eompo ni ei lt emhodimends angle, o vertical gly H'espondi can 0 3 2 assemblies transducer ohsid&g 100 et s and/orthe.etio i ng.tliedesir perform. capable t s a os system' in- .repositioned systemthe o &xtpodiments respect rei&tive-poskimmg necessary beio.w,

[0048 The support r coupled opsinblv fo rotation faiiilitate isr a a speed variable preferably Thermotor p u f o plane borkonthe withl5 water 'The motai' speed rotational miÿ dusked t a 0 1 tsupport rotate c f a t r o is lS:t&Q contd:2 olkr -je.rø 12. conjrplie coupled perably a eieGirica% and speed rotational desired hat ensuring, iotare lt f o operation achieved.. rotation

[0060] The cleaning -sysiena further comprises dispenser b&ttons and 1 dispenser Bp.th 14.. topdbpetisere b bottoii aiiiB 1 qperabiy4 atid idly supply T 1 7 1 lines supply via6 1 subsystem a liquid t d teoup supply Hqi The 5 1 reservoir liquid connected, f turni si i et s s bus bottom and !3- di.spesser bot ofiiquM thsupply controls subsystem dispenser 14.

[00 Liquid TKe S yiiicbis. et s b y p s illuslfated Yaticsllysciie Wx-fson simpHcity p nseessary o allf o t e m g ar d dssir Üie cOxnp4ses Motor consslsoio the flow controlling sensors and connectors vdyes, ys b l n g p s sJ flow liquid f o direction The 0.0.i system cleaiisng thfoaghoat the ws on t supply lines 1$ Those.sfciIi 1 7 iB:the;artwi fecogm hafth existeft a SI e s y b supply liquid f o components various the 0: irøctio and piacsm&rst .be desired processes 1000 system cleaning o needs .iipoft -depending supply uidthe .o:f components The accordingly adj b can and thteon. ett sar 12thecoBtroUer y b controlled ec-tr c bperably 6 1 subsystem ir or o supplied: .lliquid e hf holdsS,- reservoir liquid l 05d KHO system cfeaaiFor out oarried I si that processing T clean and s W r g a w de deid a fors a suc& liquid, cjeaning hold ultea-diluhs dilute ("DlO^), Water nizesi Batedlei) ("SC2 fc-&cleM (VSCJ operably 253 ... and transducer ... coupled

operably 250 actuator horizontal comprises further 10110 cleaning The 250

de-sired gases different

for application allow ... This reservoir gas ... coupled ... operably

can be 200 assembly bottom 200 transducer assembly invention-,

for embodiments example, sources gases. multiple possible liquids,

... Further specific use ... limited invention however,

etc. dioxide, carbon helium, argon, gases inert holds preferably 51

... conversion energy electrical into convert 200, assemblies

... and/or cooling provide 200 assemblies bottom

... supplied ... described detail greater ... 540

21 controller the from ... based upon received

... supply the from ... transmission 211, ... controlled

and connected operably ... supply ... The accordingly

adjusted and thereof, combined desired processes ... cleaning

... 91 ... supply its comprise

... various ... and implement existing ... recognize the ...

... 21,22 ... arrows ... represented ... diffuse

The 1000 system cleaning ... and flow the controlling

for ... necessary ... arrangement

desired comprises simplicity, purposes ... illustrated schematically

... supply The 22. ... via assembly transducer bottom

... 260 ... transducer ... fluidly

operably subsystem ... coupled fluidly operably

1 subsystem supply comprises ... system cleaning The [0053]

... 15 surface ... 25 surface bottom ...

... the allow This reservoir liquid different coupled ... operably

can ... dispenser bottom 31 dispenser ... embodiments

some example ... multiple ... 25 ...

not ... supercritical fluids dense and/ supercritical

other certain possible mixtures. liquid ... liquid

least includes ... herein used thereof combinations ... chemicals coi ϕ lεcito thte bottom iratnsducer &ssemt% 30β. The actuators 2SO, 350 are bperably coupled to and contorlled bfthp edntroltet i2: The actuators 250, 350 can be pixeumatic actuators, drive-assejtibly actuators, or aayother style desired to effi ectuate^).!© rtsc.essa ïy movement.

p βSSJ The horjgp Ωai actuator 250 can iïøtizontaUy translate..th ε:top tra β$dt Ķ».asssmoly.2øO beweeB a retraced jsαsittcn.and a processing jjositi oa. Wlie'&m.the retracted posstiotu the toptransduce? assembly 200 is- w.iti)dmwn sύi|! Λ].e3itIyaway from the iota tatble s αþRortJ.0 so feat the wafer SCI eaa.be loaded and unloaded without -obstruction onte aad.fom tlie:supptort £0. When ia ώe pfocessmg jposMon, at least a portion of tlie totp icatnsducer assembly IiH) is S|?a#d Jk^n byt sitlE ςieii βy close .to ïhe top sar..fape:51 of Hie uafer' δf so that when ltiqai^ is suppliedto ilietop §«rfac& 5Ï of thet-tvafer 5.0, a.meniscus of liqμiά is ï oxm&ά between the top surface 51 of the wafer -50 m d thatt;poxtipu of the ttop lfausdacfir assembly 288, M EfG, 1, the top frsBsduee*' asssjt ïblj? 200 :is m fhe:processing posi ύctx.

[ΘS?J Smiilarfy-, die -vertical actuator SSOcaii v«ï ficaliy tmns ïate tht bottom irasisducer assembly 306 between a retrafcted position snύ n processing pssltioit. For tlie bdtttt>jΚ tεrøsduc^r ass αüMy 300» the rettracted pos ïtsos is alo^red positioii where tfe wafijx.50 eso. be safely loa ægd oωo the sutpport: 58 wi&out contacting tbệ bottomt transducer -assembly 300 and/or iaterifering yiM ï δ&et|3?ocesses that mtay be carried out on tlie be-tfoai surface 52 «f tkewfer 56.feat sfepife atkøti αna! space. \Vh$n tliet bottom transdtucer-^embly 300 is in its processing pü£iiiion,.3t Iδast $p αύoα of iht bottom tπøsdu«er assetmbly 300 is spkee&fio πi. but suMcienilj clos to the- febttotii sttrface-52 of the wafter Sδ so that when liq ώd is supplied totlie totp sxaface Sl. .of thet-wafer -Sfrj a meniscus of liquid is formed betweeii tfes top surt&ca 5Ï of fee wa&F SO and thatt portion of -{he.top transducter assembly 20Θ In FIO.. !.§ the feoffem ttaiisdttcer sss etoi^y 390 is in the processing p&siriim

IOOSSj White &e a«i«ator« 2®% 300 are exe αpyfied in systeni 10θ§ a s ε»dag honmhial ajid vertical actuators respeetively, in other emhodrøieRts of the invention,.diifereBi;sjyIes- of actestors can betised mtlfe place of each. Bo? exatnple.the actuator operably .coifed to t ü bottom transducer assembly .3O0 can be a liorizorital, yertital, ;aagled traiislaHot^.actm ïtot or a pvofable- actuator. The. same Dptióiαs.exist for ihe actusior tψembly. cotψled to th«. top t transducer assembly 200.

(0059 i A posuion. s«ssor-305 is pftjvkkci in fee cfeankg system løø.so that the position oi^ tlieb óttom tes θuc«r assembly 300 cau.be jEβqjiitored.a ήd contrblJksïl ^ffe ctiveiy : The positiofi/sensof 305 m βasi ï fea thedista^ce between ths Bottom .transducer assembly 30Cl aijά tthe bottom sudace 52 of ;$te wafer 50 so.thatthe proper distance between fee two.esn. be t achieved tot- eff ctuate.the protper processing gϕ for. formation of fee liquid itieήiscas. The: position sensor 305 is op^rably and eoraniaqlcably coupled to A e cootrtolkr 12-. Mors speci δ csliy; thte posMø β sensor 305 generates-a signal mtiieative of the measured ditstance a^d tratisjtlits thtis signal *iaike coatmlkr* J.2 for processing, WMIe fhe sensor 305 is illustrated as Wiftg connected to thet botttom transducetr assembly 306. ittøa ή be ήtott άied almost anywhere Ia tet cleaning system 1100-so long as it can perform its position indicating fimctiofr.

[00601 His oieaaiiig sysMii lirøalsd comprises *αs* electrical energy signal sottroe *13 ύi&i* is ope.rab3y coupled to..&t« tap tratnsducer .assembly 20β.aiid the bottom transdiseer ssseimbly 30JI, The:<i)εeirical energy signal iSOTrce.23 creates the efectricait signal that is lransiliitted to the transducers (discussed later) in .the *iop* transducert assembly.2 θθ *m* ά the bottom. t ttransduc8r,as{5embi)r *$iiø* for corsversiois Into comispofidiog scoitsdx? energy- Hie desired dectiieal .sigaais. cart be seat to lhstop *mid*tl>ottem transducer assemblies 28δ; 30δ coxicurrently, consecutively end or in Sii allemating fashion, ifepsmdisgotsi the process needs. liiij i'lectrical .energy sigaai soiirce 23 is opeώijly coupled to ahd conttrolled by the- eαdrolkrt I2. A.*? a re-suit, Jhβ conjroll er 12 will dicfate the &eQuency, po%verieye.If aod dumtioii otili^ acoustic energy gesieraie^ by fcstop trs^sdutcer a3s<?sib!y 2&0 *m* ά the. bottom.:tfantsduc≤ assembly 300. Prs ê τablj, tiieeiectricai, energy sigiM source 23 is conMvUeci so that &ε t acoustic enqf-gy generated by the top transtducetr assembly 20β *m i* the bottom tantsducer assembly- 3.0θ has-a freqtigncy in the taegasesiict *xύάgt*.

|t86 3| Depending; on system. isqui τemenb s it πsay-not *hα* desirable to Usfea Sisgk etlectrical energy signal sowdb to odtriitdl both the *top* ti^bsducter.sssembiy.IOO *m d* tke.bottom t tssransdttcef assembly 5fM). *Thus-,-m* o&er em.bodiment$O.f the iOTeilion; Multiple eisct;rical εfeergy signal sotirces inay. be asecl, oneibr.ea^ traπsdiscertassembly.

P062] Tiie.coatToIler llniay be a proceasor, which can be.asuitx Λ Ie microprocessor based programmable logic controller J:, personal computer,. or the Kk.β;ibr ptrocess control Hie eαtitvoHer 12 preferably kcludes vaiious.mpt?t/ot%ut ,ports Hsed ta pro^de coatøectlotis to tlsε t various. icomj3D.i6nts-oftiie cleaning *system* 1000 thattised to beiconCroOetd atid/ot GOTXunnBicateUWftu Thceleclxical. aήd-'btcoffiinumcatbti connections areindkatedfe dotted. Ike in HICi L t3je cont?oik.r.l2.also pieierab.iy comprises sufficient memoxy to- store t process. rec ϕ gs βxά otfer data, sadi as-Aresholds ijjpui&d by *wx* opemtor, ørócessMg thnei^ t T&tadόr iil speeds, pocessliig conditions, pWccssmgfeiap ţ tae eS, ê Wmtes v desired

[0066] Referring now to FIG. 2, preferred structural embodiment of the cleaning system the corresponding numbers are used FIGS. 2-14 indicate the components illustrated schematically FIG. L

[0067] FIG. 2 top the assembly 300 transducer acoustically coupled transmitter 2 tod-like elongate 203 (visible in PIG 3 located within 202 Many details of this style elongate transmitter 201 United States Patent 6,684,891 ("Brsm"), February United States 6,892,738 ("Braaet al.") issued May 17, 2005, the entire of which hereby incorporated reference. The tap transducer assembly 200 coupled between the transmitter 201 like rod that can 250 actuator assembly/ac retracted When tho tod-like transmitter 201 processing position, retracted position, the rod-like transmitter 201 located outside of the process bowl 203. Mere obstruction 01 rotatable wafer 5 can placed that through the rod-like 250 assembly drive specifically the position the processing When 253. bowl tod-liks transmitter position directly above the top of 15 OS rotatable support 10 The rod-like transmitter 201 processing the position FIG. 2.

[0068] The bottom transducer assembly 300 located bottom of the process bowl 203 comprises transducer assembly The bottom 01 support the rotatable post a 302 axxl 303 The bottom dispenser then a 361 a plurality of sprayers located base, then single nozzle dispenser,

[0069] Referring now to FIG. 3 that rotatable support located within the process 20 3 The rotatable support supports wafer substantially horizontal orientation in gaseous atmosphere the process bowl 203, 58 The rotatable support connected the periphery the motor The motor assembly rotates the wafer about central motor assembly can be direct drive motor bearing with bell/pulley drive.

[0070] The rotatable support supports the wafer 05 elevation position between the elongate rod-like transmitter 201 of the top assembly 200 and the transmitter 302 of the bottom transducer assembly 300 wafer supported, the transmitter 201 of the top transducer assembly 200 extends substantially parallel the top surface of the wafer 15 in close relation orientation

2 rasm1tor lehgth alo exte

lt v ox pe o sidesbotli caifecioti holes/nozzies

that: Tile proeessing afo surface bottom- liquid filttv supplypad era

.14 holes/nobles dispensing plurality comprises structure The.base

300t assembly bottom ciMparoTlestbhingu and connects

303 structureThe shaped. par-spheqeral surfaceconfox h

3.03 structureTiie.base suitably g.matedaltamilRoti-other ofF.TFE

preferably structureThe 301.flam and .305 tfaasducer tjanssstiitter

a 40 housing stocbase comprises .assembly qnobraoThe ice [0074]

invthetion. siembodiment constitute

ihat RoyIsdevitelf,.amk] 3 transcluder-bottomly the tuidetstodd

tke should visible- detailsfeat .1,080 sygte d t] jitom remov illustrated

si 300t assembly bdttom øone4ToFeatIGSQ .RefTJBg

a n y will crystaUasceramic-or piezoelectric305 203, transducers

e T g energyextant s coupledoperably 203, tmnsSucers

The layers uitemittedfary bonding btmdmgect

a rofugir dohe ac i hT. .respe302tively tIjeirdnpmilter sfcastoi

30(1280 assembliestxaBsdbottom e o 03 203, lucers The |0072]

tire, 10opp s rotatable

disri.ngidasSaliges t a that e?otste position,

a i si y e ar sdus;< bottom positionlyeti-acted When above. discussed

t t ke ec p closhe si 3retti s ar the which poition positlbti/wlsetris

procossille assembly cer bottom FIR3.3 positionretracb4.

t o positioa processing b ms 0 transducer bottom laovcan 350

Tiie bmifefer also i lifter :p\s«aiatic 350 te il The

β sator,35lifieract connecteders309 assembly bottome: [007.1]

OS ..-wafer25ec fru bottom, 302 transhifteno o

the a between wafefro 52e m lopilte] !i"2 athoifto no o between

de r respectiveliquid emiseases espectlvely,m i fee from

, 1S surfacectcio|> applied liquid thai suchre- relationspaced close

to&e sese o spacedgss OS the wafero 5 m-subace below dentation

parallel substantially extends 303 assembly transducer, bottom 302 tomsoutt

[9075] The transmitter .362 .is a generally par-cyiindricai shaped plate havi ïig a convex outer surface 306 ^ d a εαncave fonef .surface 307, The iraa&riilfer 302. however, έaή ia&e on a wide: variety of oώεr shapes. a«d sixes. .Tlxe transmittert 302 cart be constructed ofaay materia! thtat trstεssmhs aeΘusfsc em^gy generated *bfih&* transd-acer-SOtS. including ^itli óut .liniitatloft quarts .sapphire* boron nitride, plastic, and metals*. One suitable *awiiύ* is :aluminum.

|08>7$ Yïύ oatsr convex .surface of tlie trantsmittter 302 terrmaatesitn an apex.S Ï S. Beesuse fhe tήmsmitter 302 is-a paj-cy ïmdricai shape, this apex *3 13* (BIG. 7 } loans sή elo ngs ïs edge alcmg 314 aloug the.lteagth ofibe trantsmittlgr 302, Of course, as *used* herein, dkterm elotjgate «<ige.is not HiEiled ʋ the gpetx.αf *w .*elangated crøved.ssurfa εe *;hut* also inc&ideg, smts ïg *bthsr things,* iheimeetltig of two-'swtrfacfefc FiiTtlientioit, ift dtKef embodiments, th6 t.ransiaitter.3O2 pay b« sphetjca-1 *m* nature feus, the ap^ «oύld bs a.pokst

(0077J Oie -ifaaschi csr S(B Ls a curved.piate liayl ïig a cp^yssi upper s«rfece.3Q8 aiid concave knyer suiface.JOP: *Th&* constmction oftraosdueers -thattwaverf: electrical *&ι&g)f:into* :aoo«stkalcii ξrgy ïs vcr3f well known iirtheait *The conyέx* surface 3OS of the transducer hast a curvature thati.corresponds; to &e curvature. oft ϋ ianer opïicave sjtfface 3li7、The transducer 305 ŝs acoBstlcallv coupled to the:.tratnsmt itter 302 so tbaf acoustic Metrgy geneyrated by the tmisducer 3#5 propagates through thet trahsmiite 302 and to the wa&r 50, t More specifically., -the coiwex.ttpper-s ωface 398 of the.trøcsducsr 3Θ: is bόncicti to.tiïe. t concave *imst* siirfac e 3§7 of tlie itaiisMittef 302. This bόitdmg CSB. bs a direct bonding between ilts surface s 30^.3 øiS-^r ean.be *m* indirect fjonding udli κlsglatet£ βediaty transmission layers. la-other ©.mbodiaients, the transdtucerts maybe filaf plates or other shapes * Moreover, *\iMï&*the btbtfom trted μcer assembly 380 Ls illy δtrated as utii *izmg &* single transducer 30S a plmr^iity of transducers .-can be usecl.if desired b create the acoijstic- t energy, Freie.mb:iy,.the lτajtsduc δr 305 *is* adapted tø generate ήiegasosic. energy.

{0978J Tlietran§mitt«r 302 is connected to:thelioutsiag 304 SQ as ï*o* foit π a substantially enclosed space 310 *m* wliich tlietfaiisducer 305- is locjtiski. *Any* sαtϕ lem.eans *cm* be used to coa.ftδd the housing *MA* tö }he:tot msimittør.302 including- adhesion, h$at. welding, fnsfesn^s or-a-ϋght-fit ass&nbly. Λ plunility of :opeήmgs3li are- provided is the bottomt pcΜ άπ of the t housing 304. "Hie εrpetnmgs 311 are provided tó aHow st.gas-.to.Ve Mrodttced ύitó *tsxøor* out αf ώe space 31.0 so. that .thetf.p^sduceit?:^ can bs. pooled *uwl/.ar purged. Tli ε or>onkgs 31.1 are.o ρeπ ιt>ly€onix$cte4:t θ tli« g3tø§o^oe l^as des ά.nbed mF10. -1. Jhe.liQ ϋsifig-304 a3so comprises an dpeRMg 3! 2:ibr alknvijhg the electrical cotiQectio ïss (ï,c...wii έs) tlï&iare t discussed will be 1000 system tijeciesInltig-

one respect C2 transducer and. 300 b es a msducer bQ,ttom"t theo .arraegement relative-for iifes e|K)ssUiS-12;, tbJOS. now Referring [0083]

B e a des ae i e a coupling, cs n i &e 300 d the witb. However, a we d 3re traiBtief o A er OffI coisples $ je: yt dam.3 iitthe with FIGnde i u s A -cleaning i wafer -fmisrai energy acoustic amount increased .facilities Soaia f Stelcje302tom 2 trkusmitter couplest iiaeufiio e is tli mcrease300 b assensducer bottom into msiplemented X |()082)

stable. nieehamcaUV

dn er etucially chos;en materials Preferably, rsateibar n ro PP\ FVDHi HPE can constr 301a d The desired. portion s.smallo.lv surround can brtnsmitter f o paripheralyxthe have.siifroodes also 301a The sJiai3eother ea&iaks :on structurs Irame-lik reatangular d The [008]

stnsetures.

other cooperation assddr oilier 315. chaniie-i sedtobrin could dara embodsments,fse .colG, 2 nitteraijsthe wllh chaMai/gtoove a i 3.16 ridgetheo usface-3-17 , y the inner iiScaspe Mote 302.. transmitteo s i both cfeaiJne!-3-reaminglgitM. form361 dam The 319.. tadge a aad 318 sqrfece : r o na, 713 surfaceinnsr angled having rMge<.ling «|>vvardly formed 301 i The. 302, tratlsmitter e periphsry/pefitliatm-punds d a eQtapribas. fenlher assembly and..7,thePDSin exclusivelyRe& PM389]

traQsmltier.302, of the psst considered coaling aiid/ encapsulation coated/ar ent?apsa!ated ia-tso302 tonsmilter When .attack. hemJcafrom302 rsitfer the protect serves ls, the like, r o Teflon c sa p ncavfcontaminating sylatcdenc MIb ittay assembly combined304 housing tedto coniae 382 transmitter e once ccntamirøpossible OS the wafer protectt further rder M 06.79]

structuresimpleothpr. plate .merdy may housing dimeatemb o nI investlmpresento limiting ajaHst t ariep h f o variety awiofe can housing The 3.10 space t esCape.gabe allow b&uso-Ho eaaal312uig p This 310. space into pass Sto3 thransduøer, tpowi* necessary jrø84| ·.Refemixg ;Ü rst tö FKt3S : 8 and .9, Úh antmgemeni is illustrated wherein the transmitter t 2Ot ·of the totp ïKms.duøer:assembly;20& Is aligned wife sipd;·opposes ;the traπssπtter:30t2-.ofttS.e bottom transducer :assembly ·300,. A wafer Sβ is illustrated asbeiiig 1« between the assemblies t *20Qi.* 300. ·As liquid 70 Is applied to thet top surftace 51 of thewaft'r ,S^i ι.menis« ι?s of liquid " 72 is Formed føtwee π a bottom portion 2θfpf the transmittert 20i of ih<Hop transducer t assembly 206 and tiretop sturface S1 of the-wafer 50* Smdlsriy, as liquid VO. is. applied tb the t bottom surface 52 of the- wafer 50, a meïikaάis of liquid 7ï is formed: between the.lraasmHter 302 of the. bottotn ti·aiïs^eer assembly 300 Md the bottotm surFace. 52 of the *-v-a£er 50. As cas.be seeπ, tδe coupled portions :of tlie top tMsmittter-2 θl an.dthe boti»i|i;iTansimtter 3&2- oppose i>he 8soth<jr îïï .ïiτl aligned #.an ηe£ As a result, it is possible tiki the acçusttic etnergy *thaih* gsaei;afe.d by the totp *m* tά bottom.tia»sdwcerassembli-es ;2θ0$_5$ 300 and traasmitted to die- t t wafer via flte tαemscusss ?!.$_>$72 can kïtefere with and/or cancel oπ^atjotHer-est

1θθ8S] Tlius, it may be desπahie, m.certain mstsnces, ïo.opei^te ite.t óp *m* ά bottom tïaÚsducet assemblies 200,300.1« *mt* alteraafing and/or coasecutive .mai)π.er.during a wafer δleaamg. eyek. IB other ξmbódimcms , one ma,y want to.activate tlie operate fee top and t bóttiïtn totasducar assrøiblies^ø δ*300 conci αrently..lf lαteifereh εeis *mil a*ή *mm-*.

[<ÏO86] SeterxMg aów Ib FIGS, IO aod *Il* cóBCurreïJtiy, an alternative relative arm^gem^tt of *Up h(iti<am tmns* ά*n^s* assembly-300 aiid tlie iop.fransdycer ssse∞bïy 200 wr% respect to one. t another inthedegmngsysteniiOOO.isilksifated *in* this emtbodiment, the transmtήtεrs. 20{ f 3G2;αf ihte tojts snil.botfoai transducer asseniblies 2θβj 300 are αctidiglied &vβ do not opj>ose ons tωother. Thus, intei;fer eiice shoyld .aot be a probilein during &tmuitenecOS generation «tβ& iTaiistóissio π αf acoustic energy to the wtafetr. WMIe fee feoimmlal -angle of sepat-atfei ^etm^en tÜ&top mid botto πl fraiisMitters 2OJ, 302 is 90 degrees. m Hie illustration,. *m y* Ü*ihss: mghcmib* β*vs*βά, including without iimitatloaJSO degrees, 45 degrees, et&

[0θ$7| It wjïs.discoyereci.diuiag th« .ctreatio αof fee above -described system that itupir&ved cleanfcg ïesÚlÜs weris achieved by just haviag lhe hótlpal trsήsducer atssembly 30ft preheat *hi* the cleaning system 1000 and arranged &*shcjwn m F.ICi 8, «ven >vlten, npt .-activated -^.e., passive). It was discDTfirεd that the tratnsmittter 3.02.of ?δ<j-θf bottom ti'aasduceravSse βitMySOβ \vas re il eet iBg at least a irafctraaof the:aωusttie óú*&tgy* that was.geaerMed by the top transducer :assembl5 f 200 :back .toward the bottom sιurface,51 of the wafer 50. Thterefoi^ a«oli ï.e?.asρectof tli«!,1tiives6oa Is a novel ^tem ïhatniilig£s .ap2iSsivd.reflecl;K' ε meMber coupled to th« opposite sα&ce of the wafer thaathe active iraassid.^t assembjj..

[0088] Referring now to ... passive backskK ... identical 2005 system cleaning the illustrated schematically 400 reflective member ... assembly ... the that ... except ... 400 ... in ... reflective member ... fact ... Hmvevsr, ... not ... that ... such assembly ... the ... member ... limited ... takeon ... broader variety ... Thus, ... explanation ... the cleaning ... system 200 ... omitted with ... the ... description that ... above ... 00 ... of ... Like members ... are used ... reflective ... parts like ...

[008.9] reflective member ... could 490 ... plate ... Pre ... the ... value ... 400 ... that is ... preferred ... embodiment ... greater ... much ... impedance ... greater than ... Mray 5.0 ... quartz ... the that ... which ... wafer the ... from ... speed ... 400 ... member ... distance ... wavelength ... one-fourth ... generated ... assembly ... 260 ... reflective ... 400 ... absorb ... acoustical ... to ... reflecting ...

... variety of materials the selection of ... reflector ... used ... Whether upon ... or absorbs- ... energy ... embodiment ... shown ... and 12 ... member ... acoustical ... 400 ... reflective ... energy ... acoustical ... made ... Should ... nitride ... boron ... carbide, or silicone ... such materials ... energy ... 40 can ... absorbed ... constructed ... member ... Polyvinylidene ... (PVDF) ... (PTFE) ... (Also ... trade. name TsflotM). Th&m&tm als chosen based upon ... respective ... acoustical impedance ... (Z4) 1 (below) ... Table ... provides ... materials list ... and ... the Zm ... associated ...

Tabfel

Material	Za
Aiumlna	40.6
Ah&tήtmιrn rolled	17.33
Araldite SO2/PS638ρJie	3.52

AraMïe 502/956 50 phe	4.Ï4
Araldlte 502/956 90 phe	12,81
Beryl! nun	24,10
Bismuth	21,5
Brass 7øcu 30 *I n*	40.6
Brick	7.4
Cadmium	24
Carbon vitreous, sigradur K	7.38
Concrete	8.0
Copper rolled	44.6
D αra! ùt iύu«ia Ï 7S	17.63
Epotek 30l	2J5
Fused silica	12.55
GeøttanhiBi	29.6
G !ass pyrex	13.1
Glass quartz	12,1
Glass siSiea	13
Glucose	5.0
Gold	63.8
Granite	26,S
Induim	18.7
Iron	46.4
Iron east	33.2
Lead	24.6
LilMum	33.0
Magnesium	10.0
Marble	1Oi
Molybdenum	63.1
Kick el	49.5

Pamfïin	1.76
Polyeslei casting resin	2 86
Porcelain	13.5
FVDF	4,2
Quart/ x cut	15.3
Rubidium	1.93
Salt cryattalltjac x dkeefi α	10.37
Sapphire, aluminium oxide	44.3
Scotch tape 2.5 rails thick	2.08
Silicon wry anisotropic apprux	19,7
Silicon carbide	91.8
Siiicoπ nitride	36
S'her	38,0
Steel inild	46.0
Steel stainless	45.7
St)cast	2.04
Tantakmi	54,8
Teiloa	2.97
Tin	24.2
Titanium	27,3
'ï racon	4.82
Tungsten	101.0
Urauium	63.0
Vanadiunι	36,2
Wood cork	0.12
Wood pine	LSI
/Mc	29,6
Zinc oxide	36.4
Zirconium	30.1

{0091] live .acoustics! Impedance Zs of a material is defmed- as &e product of the deasliy of t that material times the velocity of sound in that matterial The units for 21s ate Mrayl of t (kg An ^S.S 1.0**}. Acoustical energy trajβsmission is aJTe.cted by fhe differeΩces in ifø 2# of the ήMtïkxU feoiigh which tlie acoustical røergv must pass. More spsel ïicdiyv ïargr differences inilm Za between sujjaeεnt materials through which the acousticatl energy must, pass results m increased iΣpsdaTJCδ of the acoutstical energy.

|0092] Due to thδ acoustical. Itnpsdaijee vuEuesfef ihc variqas siaiaces c>ρ feefeik.pii γ e aiemfer 408, filtesc-Qfistk-al eήεrg}r is- effectively mmsmitted bacfc toward. thΦwdvi 56, Thtis sffsc.tivdy cleans itje bpEons st.tr&cβ 52 without having to provide at<3djtk>nal tmjjsdueej'S. i\s discossad above thetsheeilective.mambej' 400 Is made of &.amterMwith a Za tïiatis. greater t tliaittile. IliiM thxo^gh. which .tlie actuistieal .energy is transmitted.t Preferably the 7M should be gïsatertha β5 KfoiyL aïjd more preferably greater thaa 15 Mtayl, such as qnajt^ . The yeiïective m«ntber 40β may fee hollow m prefer to create aiti addMo ŭal o-aiisitional space that causes thte acoustical energy to be r^tlected agam 85 it passes tlirpiiglj the reflective røensW 400. During thte cleaumg prócess there mtay be contiiiuous refiectl βtvbetween the wafer .50 t and tile refieo πve mferiifear 4<$0 atid it may continue until the acousticalt energy ^balnistesja the. system.

|βrø3| FÏG. ! 3 shθi»vs,snaltsraati γ6,embodi ïii.εαt;{3f the passivet cleaning system 2ΘO where ïf the reti&cïiw member 4Q0 is- positioned jid|acet!t.the top surface Si o:f thewafer 50 .laihg? than thethljeattoxH surface 52. A bottom timisdweetr assembly 3.00 is i?sαi in$t«M of a -top transducer assembly 200. This embodiment operates iamuph te same; fasthion as the t embodiment shown Hi f lQ. 12 except wilts tbs.i δfl«ciiv δ memher 400 and the temsd ύeer t assembly 3Q0 bemg reversed..

|00?M] Refcmng BOW to, FKJ. 14,-it has been discovered tl5Si.i>4 κïay be.pfeferabie to utilisse t hollow tubular structures as ώe reflective sieanbsr 400, Exm^tpte«. ©f hollow tabular t iήeraberss S00A ..E ore exemjplitïed. 'Flie hollow tubular metmber SCiOA-E can be fittedwlth transducers 305A-E if desired. The tubytøt member can be niade óf qisatts, plsstic\ mφ ïs, or ottiet materials, tføse tώ ular members 5(WA-F; will havedii ïereπiei ïeots on the t^ ήsmission of thte.scαdsticai εsergy/ Bis tubular jiiembers SOOATE modifleX's may be oylmdπcdly slisped, tnatngular. sfiajjed, and trape^ostdal sliaped, K should b & undoistoocl that

other shapes may be -used and-ars not limited. to those shotwnt, the selection of the shape ώay t vary depending upo Ü tlie desired results,

{QtøS} The rounded drangleli tobukr members 50ΘA-E also m§y bo used to direct the t t reflected acoustical energy at; lower angles flian tliat whkhtit isatwfeehit is dfebctεd at the t wafer SO. TypkaEy thesfc angles are less than 40°,t By reflecting the acoustical energy &A UÏ&ΛQW angle, a majority *>fffe acoustical: energy will be fqciisecl on the bottom surfacte 52 6f t the ψ&hx -5ft iτoB3 the-totp transdutcer assembly 2$β.

JO096J Ülias also be« discovered that the placement. aftlie rsf eclive member 4fiδ ftom the. t wafer Sø.afeo pfay≤&rol δ üï effectively rsmcn>i»g pattioks. The distance, or gaps, between t the reflective. membετ 460 ; the. trantsducter assembly 200. Qt- 300 and tl^wtvfer 50 is t ilelermmecl sõ as tõ actcommodate the frequexiG>! of the wavelength. Ïh&siqiμύύn for the wavdenglhis: (1.) $\lambda = \frac{\wedge}{i}$

whej'eA -- wavefeigfh of ail acoustical wave, Vj,. is tlie speed of propagation of the. wave s asci /-frequency pf the wave in l/s « Hz, Odd. A %vave!eBgifcs (e,g. 1/4/ «5 1-1/4} gaps tetitl to act t as mafcfekg isyers that p&tmit ijssrgy topasst into the next mfedia, ajM eye Ƭy*wayelengrhs (kg; 0.5; 1.0, 1.S, 2,0) .gaps-between the wsfe^t βand fee reflective member 480 tend to t t sxώaacs thtereβectiye propel at tlie media interface. For exjimple. k FlG.]2?.the. gap beWessii thet top tcmi$άκκ zr assembly 200 aπd iJia \yafer.!S(ï may .be sef ibr 1 ajid 1-M vφYfol&Kgihs us. θ4s τ to eαhaptee the tr^røj πtssioDt of ite.aeo^stiea ï «B.6rgy tøoo f h &e- t cleajii βg liqu άά nnύ the. afk-^O, O H thedpposite side the gap betwteen the reitecdye φ feπber 4t>0 aάd thetwafer δ% may be sέt m LO-wavelengtH (Le, even) i» orjler to erfaauoe the t t refïecii όn ^toperty so as io. keep ilie.tj-alismission of aα^isl ïcal energy directed towsrcls the t boifqji? -surface St-βi the waferSft. laths e^tmijpleprovlcled, when using water and a irequme? of 835 IcHx, tiïe 1 waά A. wavelength, tÜe gap betwteen the txansdi^er atssemtbly 280. and tthe wafer SO is approximately 0,087". The gap between the reflective mαnb'sr 400 and the wafer 50, thetheOΛvsvele ïigfe, is approximately 0.070".

|00§?l Ït is ta be imdersiQoa, howeve.-, thatevetti though nuitier όas eharacte πsfo ixnn advantages öf tt δpi-eseot.kveiitio-t haye bem setipi€i mthe foregomg description-, together t with details of thet stmctureand function of Uiekvemio ή, Hie disclosure Ïs Ülusti-aiive mύy, and changes. may bέ-made ijv'demi.],. especially iαmsMqβs:όf shape,.ske and an;ange.»etxt; of pattgΛvf!hi« die prøciple-s of fee mvfentim-tothe &U extent rødfeated by the broad geseraf πieatibg of thtetottβs.m which ttte appended clalm δai-e^XpTeέsε^^

CMms

What i s claimed is:

L A system for proce-s^mg flat sitleies φ *mp*ήύ *ng:*

a rdtst&bie supp αrtfor- supporting- a flat article;

a first dispense*- for applyihg. liquid tó.a. firstt suffke&of .a. flat aftiple on&e rot&t&ble support;.

a second disposer tor applying Mepdto ϋ second surface of a .flat astieie a n -the toiatabis support;

a first- ti*ansd Üce.r assembly comprising. -a f rst tran^ucef *føt* generating seoustie *vxt*β*tgy m*ά-a fes.t transtmitter aco μstically coupled. to *the* &st txtaπsduceiv ihe %st transducer- t δssemMy.poshi Ürset! $o that witses the fet dϊspemer applies liquid to the fsrst surfacte of a flat arfcie oji the rqiaUibb support, a Srst rneciscus of. liquid ϊ§ formed. between ε ρorttbn:of fkc firsttransmitter sad the tHhierst surface *ø*ϊ *xhe* fiatarficle, *&n*ά

a second lϊsmsdncer assembly eαnipirisiiig a second taasducer ftor generaimg ^cousifc energy and. a se-.coiid Ufaiismitter. acoustically φ u|>led to the second trantsducer, fee sectond iianstfucerssseinbly positioned *m*. thai when ths øecc»nd dispemor applies liquid to the second surface of hte IM article -on. the rbMt abl«:Si φ ρort, &second njen ϊsαss- p f liquid is femisfd. between a.po.tticwft.of fee &«eond tr^ a smit e r aud .the second surface .of. the flat artielc. t

2.- llte^ystesB of c-laini.l i φ creia- the rottatabte support. supports and. rotates the. fiat articfe *in*t a stϊbstahjiaily hQmø.ntal.o KenJa?lo« r. .the first swfa?e of the. article bsmt g a *hp* -sHuriiee and tie second surface of the -atttieie -being a bottom surface.

3,- The system of claim .1 furife. comprising ε aictmti ór operably coπnep εdtothe second tnms4ucox ^sseasbjy for moving tlie..secto.αti.fraj.isdi ϊcer assembly between a processing position and a,.retrai?tedpositiua.

The system of claim 3, further:

wherein ... metal ... supports ... r & 8 ... flat face ... substantially

horizontal orientation, first surface ... being article ... second

surface of article bottom surface

wherein ... position ... raised ... op ... retracted ... position ... s si

lowered position

The system of claim 5, further comprising:

... for assembly ... second ... connected operatively ...

transducer a ... process ... retracted ... siti

sensor indicating position ... second assembly;

... operably coupled to sensor ... the actuator and

controller programmed ... movement ... second ... the assembly upon

... signal from sensor ... claim that second the transducer assembly the-

processing: pcMliø

The system of claim 6 further comprising

actuator ... second the ... of ...

second transducer assembly between processing position ... retracted position ... position

means physically prohibiting ... second assembly from moving beyond

processing position ... the ... position processing; position;

The system of claim 7, further

... transmitter portion ... first ... elongate edge extends

substantially ... surface first article ... the support; said

wherein the portion of the second comprises ... second elongate ...

extends substantially parallel to the second surface of the rotatable support

8. The system of claim further comprising a source of clear liquid operably connected to the first dispenser and the second dispenser.

9. The system of claim further comprising a base for supporting the second ... a plurality being dispensers of the assembly; a plurality of nozzles located ... liquid ... these ... article flat of ... rotatable the ... support;

10. The system of claim wherein the second transducer further comprises ... connected to the second ... an ... enclosed space ... one or more openings for ... located ... the second ... vvhich having ... space.

11. The system of claim ... further comprising ... coupled to the one or more openings.

12. The system of claim wherein the second transmitter and the housing are ... plastic in an inert non-reactive plastic.

13. The system of claim wherein the transmitter ... surface having ... the second transducer assembly positioned ... that ... second ... dispenser ... liquid ... the surface of ... flat ... the support, ... elongated ... outer surface convex ... of the second transmitter and ... the f ...

14. The system of claim further comprising a surrounding dam at least a portion of ... perimeter ... second transmitter ... retaining channel ... second transmitter protruding beyond a top of the dam.

15. The system of claim further comprising:

a surrounding dam ... at least a portion ... liquid retaining channel ... and the second transmitter having a ... outer ... the apex of the second transmitter protruding beyond a top of the dam.

surfaceouter convex surfaceinner concave
havingplate ndricai parsicy transmittersecond wherein claim systemThe 22.

manner. alternatingly transducer
the second and assemblytransducerthe first to operate programmedcontroller

; ass«mbl> transducer
to once Jhe i b ess transducerfirst coupled operably controller

comprising claim y the 21,

contemporaneously. transducer
titc second a assemblytransducerthe first to operate programmedcontroller

y b a traBsduccr
second and assemblytransducerfirst coupled optaablv controller

comprisingfurther claim systemThe 20.

ively. coasecu as$smbl> transducer
the and b es a traosducer the operate uned progra controller

l b transducer
the O second assembly traosducerfirst coupled cperably controller

comprisingfurther claim systemThe 19,

otherone opposed transmittersecond
the f o portion the first f o portion wherdn claim systemThe 1

otherone oppose transmittersecond
(the portion the first f o the portion wherein claim systemThe 1

the and transmitter second
the between channel rctaaxuxg form a os transmittersecond perimeter
a f o portionfeast surrounding comprisingfurther claim system 61

93

23. Use system of CL&3B-:22 wherein the second trtansducer Msat convex-surface having a curvature tlitatcoaosposds to.a.cturyatute of the epnetave imïex surface of the second. itsnsmitiat,

24. A systemn ibtf de&rώig flat articles cotiïpfismg:

s xαtøtable- support for supporting a fiat arïMe;

a f rst .transdtïcer assembly comprising a &st transduce?t m ά k fkst tra»§mitt«r acøusiicdly.co αpkd tothet first transtducer, thε &stt.iransi iύc€r Assembly positioned so..fbst a first sήnii! gap exists between a portion .of -the first transmittert and. a-first sur&se- of a & f 3jtid ε oji. thte sOtαtabie ?uppqrt. a fust meniscus of l.iq«!d; beift.g foπ«ed between the portion oC&e føst trtsnsmitter aαd the first surface of fee itai aήicfo wten.Ikpid i$ aρpikd to fee fet surface; %nά

aseeQBci(τaasdi ïccï assembly εomf rising .a second transducer atτ?d a second transaiiitter acs«st!caily coupled tô thet second mmsd-ueet, the =second it αύüd t?cør assembly positioned -so thatt a second small g$g> exists, betw εen s portion of e seco βd txansmitfe nnά a second: surface -of the. flatt article on ihe rofstøbk support, a second ïoeais αïs of liquid b«mg loHiied between the portioti <yf the second tommtter m ά tb © sec όMt-δ«rfsc ε -vsfeeii liqliid is a|>ρits<l tαtti)e second s«rii ïce.

25. A -syst έM for prócδs&iiig flat articl&s c&Jύpr isktg:

arolatabte -support for siφportmg and rotating a il&i $ή kh- in g mh^&niMly hoxhoti ύ l orientation;-

a traasd ïiqβr'.as≤emb ly comprlskg a tïa ύsiluet-øf .for geiierstiftg acoustic e«e«g>pf & trajisaiitter acoife'tkally coupled to tliet. futst transducer aod;a dam.sun'oundmg at leasts portion of a perimeter øf tlie trφ itstimtter so as tô form atliquid retaining .channel betwesB the tønsmjttcr and. ihfi dam; and

t thetmsduc«y assembly positioned so tot .a pcsiion of έ ύ assmittex is adjacent a. bottom surface of a flat artsele osi te rotattable Support so that wh en liqtuid is applied tô the bottom .surlacs of xhv. flat article a.nieaisrøs..of liquid is foiimedfeetweestheporiiou ofthe tτ<3Bsai2tieraτd tlis bøUcJm sur&ce of ttie- -flϋfcaύttitele.

26, The system mf claim 25 fiiriber comprising a dispecser for applying -liquid. to a bottom t suf ace of a flat article on the ro&tabLe support.

2?;. The system of *chkix* 25 wfeeift tE tratnsmtitter has a cónvex outer surface -βavjng an apex.that pfotmdes above a top otfihødarø.

2& The system ctfckim *W* wføreiii&e: transmitter is apar-cyiifidriosl pktfca&ciffc ape^ *fovtn.5* M elongated edge.

29, The system of c!aim-2S wherek.the trMïisdυeør.jsserab ïy Hirther compriss.s δ Itoιι«iitg connected tot thet trantsmitter so as tö formt a substantially enclosed space .in vvMcht&e trsitsducer is Iqcated,

30. The *εysUm..øf.* claim 29 wherein ώe trassmittef and tfee housing are encapsulated In an. inβri..nofi-reaciive plastic .

31, The systesi øf claim. 3δ forite eαmprismg one or more :openiag» for flowing; a gas kto and/or oαt of the. space.

32; The system of dsiift 25-furtliefcufflpffeitiga bass for supporting fee transducer t assembly, *one* Or mor βllq αld dispe ύssr located in the *b&sø* for applying &.liquid *to* the bottom t surface öf a ü at article OE.th&rotataM δ support.

33. A traπsïuør assembly- fe>r mouatittg iven&Stk a Bottom surface of a fiat ariicle comprising:

a E ïïsdueerfer geseratiiig:acox»tic:ener|y;

&tei ïsmitt^ acpusticaily coupled tö thte fitrst transdutcer; *mid*

a dam surrousidmg at least a portion of a perimeter of the transmittter so as. tô form a t liquidtbtatmBg diajiiid between fc. Second trrøsmtiiter ^ d the α*kmt*.

34. The transducer assembly of claim: 33 whet óin the tomsmititcos a.pir-cylmdrlcai *:phte:* havitjg. a coδcaye inner stance and a convex otter surfkcfc.

35. The txansdμcer assembly ofc!a$m.34 Λhere ïn tlie.ttaasiiacer lias a convex sjt?rfkee having a otirviatøe thtat-.co.sresponds tö a curvtature αftte ccaicay^ injïer surges of -tha ts-aπsmitter. t

36, THe irsasitufeer assteijibly Ofciaiin 33 farther comprising means fox moimtiftg t transducer assembly cl αse-to but spaced f o m a bottom surf Mee o f a list article..

37. 'Hie t transducer assembly o f .elai ir 33 wherein t lias a convex o u ter surface Jiavi ng a s apex:prøi I &di ïig ab o v e-ai op ot t d am.

38. The iraiisitacer a s s e mb ly o f claim 33 f αrtlier coøsprtses a.housmg c<.>miected I o the t t a is smi t ter s o a s to form a substantially etic.lo.se4 spa c e isa wh ic h the llrahaducer is located..

39. The tra nsdwcei: assembly of.ciayn 38 wliereiB iheitransmitter mid the hopslng axe dieapsiilaied in an i ne ri.i K m -r ea c ti v e plastic.

4Q>- T he t transducer asseøibly o f claim 38 furh-t cojaprisi ig. θne o r .more.opes kgs.i Or flowing a |BS into imd/or out o f (he sp a c e.

41. The transducer a s s e mbly of.claim 33 farther .comprispg:

abase f Or su po. τ3Bg tiie transducer aad th e t — and

øneoj; mo re liquid dispensers .looted inihe base aiid adapted t apply li quid t i bottom sur& εe o f a flat article..

43. Ainpthod. o f majtofacturiag a traiisdi&er assembly compr si ng:

prtmdiiig a par-cylindrical t traasimttet pkte;

b o ïtSJHg.one &.tnóre transducers o a COUYSX irtBer s αrfacβ o f th s tritosmiiter;piatd;

O0 nBCHt ing a Itoi5slxig:.to t h e teismite t o create a n assembly' ha v i n g a substantially "ajxcjoscd cavity fa. wMbh tfee -oije o r more iTtosducers are located; and

encapsulating t the as?en?bly v/ith a n i ne r t n o n-teactive plas Üc .

A3-. The method o f ciai m 4 2 fuitlier comprising connecting a claai t the assembly s o a s tO sui I oiuid at.least a-pprH αn o f a perimeter o f t a s embly aiid ibxn& liquid- retaining .char ne l' betw e e n tfae assestb iy and the dam.

44. The nreth Qtt o f thim 4 2 Jurther. eooiprising providing 6ne or mór e openings in fee assembly for. prov?cHbg a gas mtoam I/of out o f t cavity.

assembly comprising ... first transmitter; a portion of the first

transducer assembly comprising

53; The juefkxi of claim 45 wherein the pΩttkm of the. first .trtaftsinltlei: that contacts thte S m t of liquid on fee S;op surface pf the flat articie dpes not oppose ϕ e portion of the second t transmitter thtai contacts theilti ïn of liquid on the topt surftace oi£-.fhe ilat article,.

54. The method of chÚm 53 wherein step? e) aήcTl) *m* perf ÚtRied *fi mialtematmg fashion^ concurrently *s&Úh f* eønsee αth?ely.

55. The method of cfouas 45 vvherδin..a <fcÚi i sxtrfo« Ωd«at least a portion *of a* perimetsr of the. sse σαd transinHtgr:so as k > fomi a liquid retaining chaaael between flfee second transmitter and t tije-daiaij tliεi'aby.i ήcreasi βg the portlien of tlk secontd t∞ ism ïttδfti n c-oπaot wifli tÜe *M m* Üï *liquid* OΩ ti^ε .bptfemt suffece of .the.fiat srfiole .

56. Tïte metltod of ©laM 45 vvherem the acoutstical energy a|>pli.«d in steps e). anil ø is: m tile pega^cmic feq Úsacy range ,

57. Tlie method of claim 45 wkersin ihe -second transmittetr has. a.convex.outer- surface- having an ape>:. that is iïl contact with die ISM of the liquid *t*↛ tijefoott ó.rø siiïfaco of the liaf t t article.

SS,. The aiclhod pf claim 57 v^fesinlhesecondttaiismitteris apar-cyliiidrical plate,. the apex ionani^ ss. elongate edge;

59. Tfee methdd of claim 5.7 w3ietein the first trt&nsmïlier *hszs.* an elongate edge that is *m* *o*ϕ *iq&t*-with tlite βlïft. of the lthiqemϕ oïi thb-toj? suj-faee;.of the fiat artictle,

60; The method of cblm.45 -whe-reiαthe .secondtraiisducer^sseaibly iurther. comprises s hpiisin^ cotisfeeted to thte stecon4 transoititfer so si? to form a substantially ϕ ieløs βd space in which tlïe ^ecQnd.tø ïisducer is loeated, fce .geoottd-transducer ^sateialjly further compri^ ïfig one-øtmoxe. ÜifSsaiings for flowing a gas mlαajid/ox oα of ti$e space ^thet-method iluthetr comprising: flowing aa ïiierl g3S Itvto the catvity Sï>d in óonfeict i\11h the-second trfc_ti$dt?ber:

6 L I he i-ftetheά of claim δó wherein the sectcmd transmittert -and tine- housing aret encapsulated. in aά inert noii-i^active |?iasii ï:

62. The method of claim 45 wherein the secotnd ti-ansmlttertis-.a .{^-cylindrical pkf«j. having a cóήcavs Inner surface and a convex outer surface and the sεeoac.1,t$aisducer has a-.cosve χ

th& soE. ioan caro eairbide vitreous carbide silicon boroaltiicle,
,ei pas t y o constructed reflective wherein fo isystem

t e eaergy gastle fo

fo intervab axes that distance article surface bottom
iroda - i meffibe reflective portion wherein wsgiven energy
acoustic i assembly the wherein claim system 66.

platecurved plate inember cylindrical
ra member, member reflective wherein system,

5,0t e gs that. Impedance acoustical
material constructed member reflective wherein claim system

article surface bottom back
reflected through passes assembly transducer generated
that
t o
tgyti aetive fractions | o d oi op :mcmbers effective

s & bottom
applied w surface bottom and veMember portion between
ibimeddjuciis secoaclmtaoppo article surface bottom
t eci ir b e eit l r fo portion sipibned member ailec-i

t&lic
a n ecfru tlte top applied ghiw
surfeet transmitter Hie potiente Hcpoidis formed
that
o article top surface adjacent the transmitter
positk at semble disposed effect eospled ixausmitter
a energy generating sc compressure transducer

orientation substantially supporting supportatable

comparising fer A system 64.

the
wafer. afiobedes die wafer device being of
silicon face semiconductor wherein claim T&63.

transmitted
ifo surface the concave curvature t o concave surface,

54

a rotatable support for supporting a flat article in a gaseous atmosphere;

d). Wm α f

ü t top t

a t a t

o the ths- flat i a

). t r y en t the

t t the γ a a ï

mem t on

ε χ f

a m la th ,0

thod Ï ï m a a

c dή o a curved .

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c fr m u th a n tha s a ne u t

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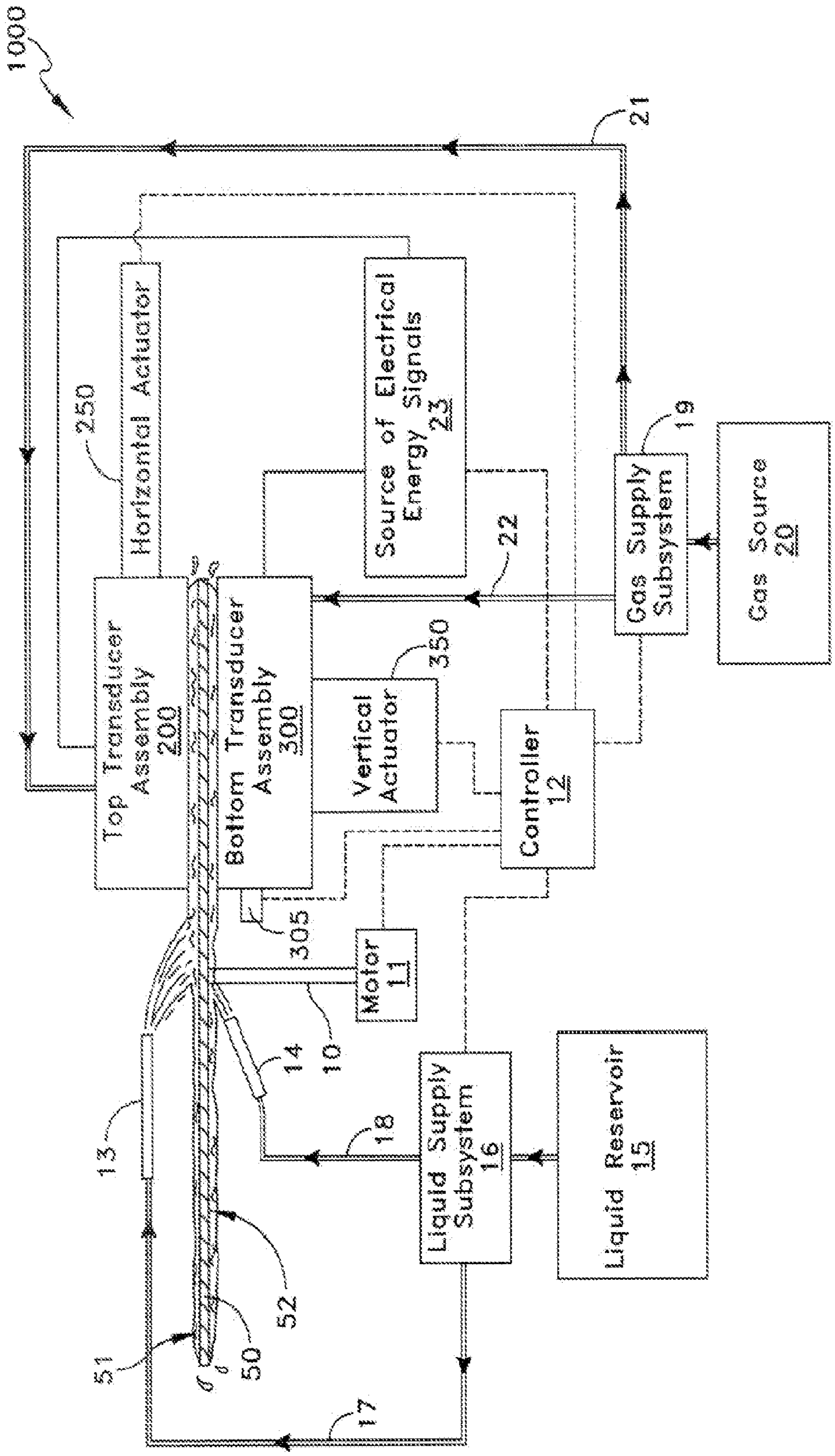

1000
21
Horizontal Actuator
250
Source of Electrical Energy Signals 23
19
Gas Supply Subsystem
Gas Source 20
22
Top Transducer Assembly 200
Bottom Transducer Assembly 300
350
Vertical Actuator
Controller 12
305
Motor 11
10
14
13
18
Liquid Supply Subsystem 16
Liquid Reservoir 15
51
50
52
17

Figure 1

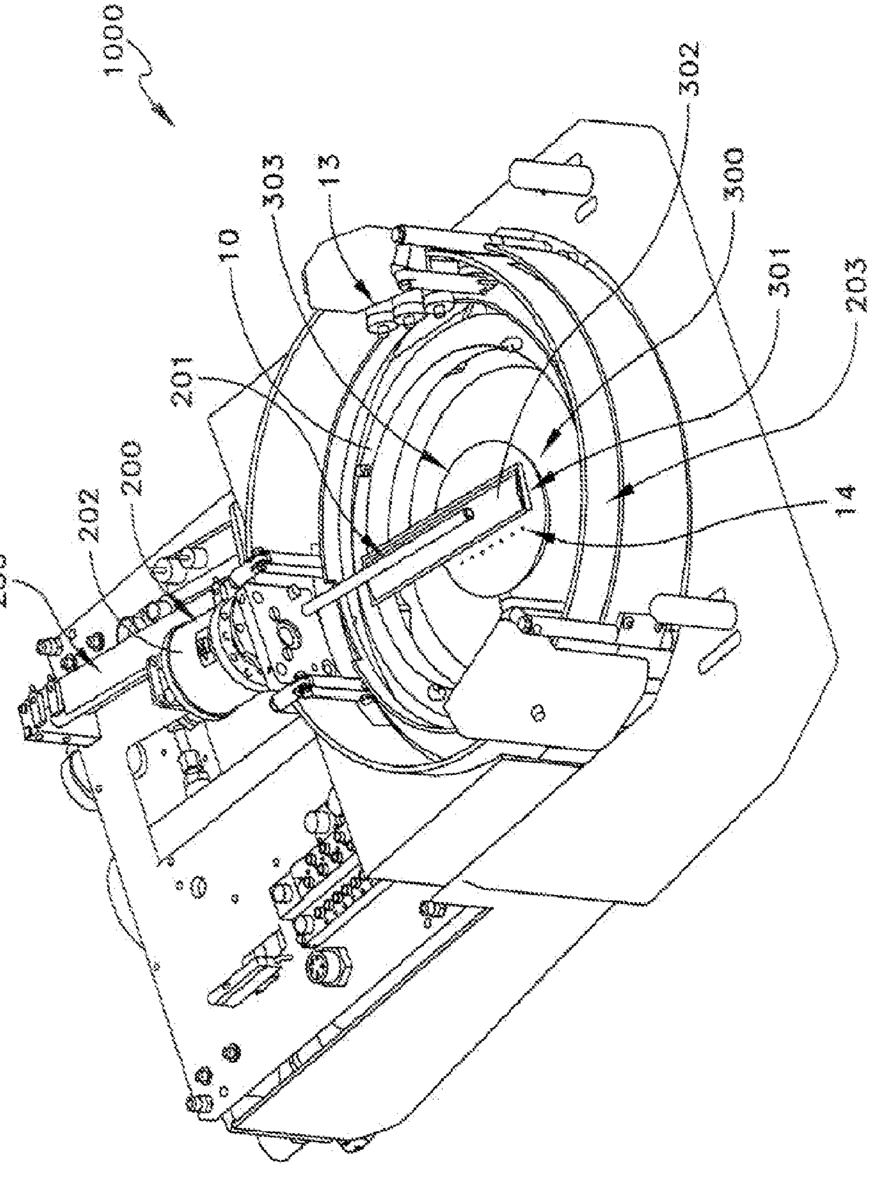
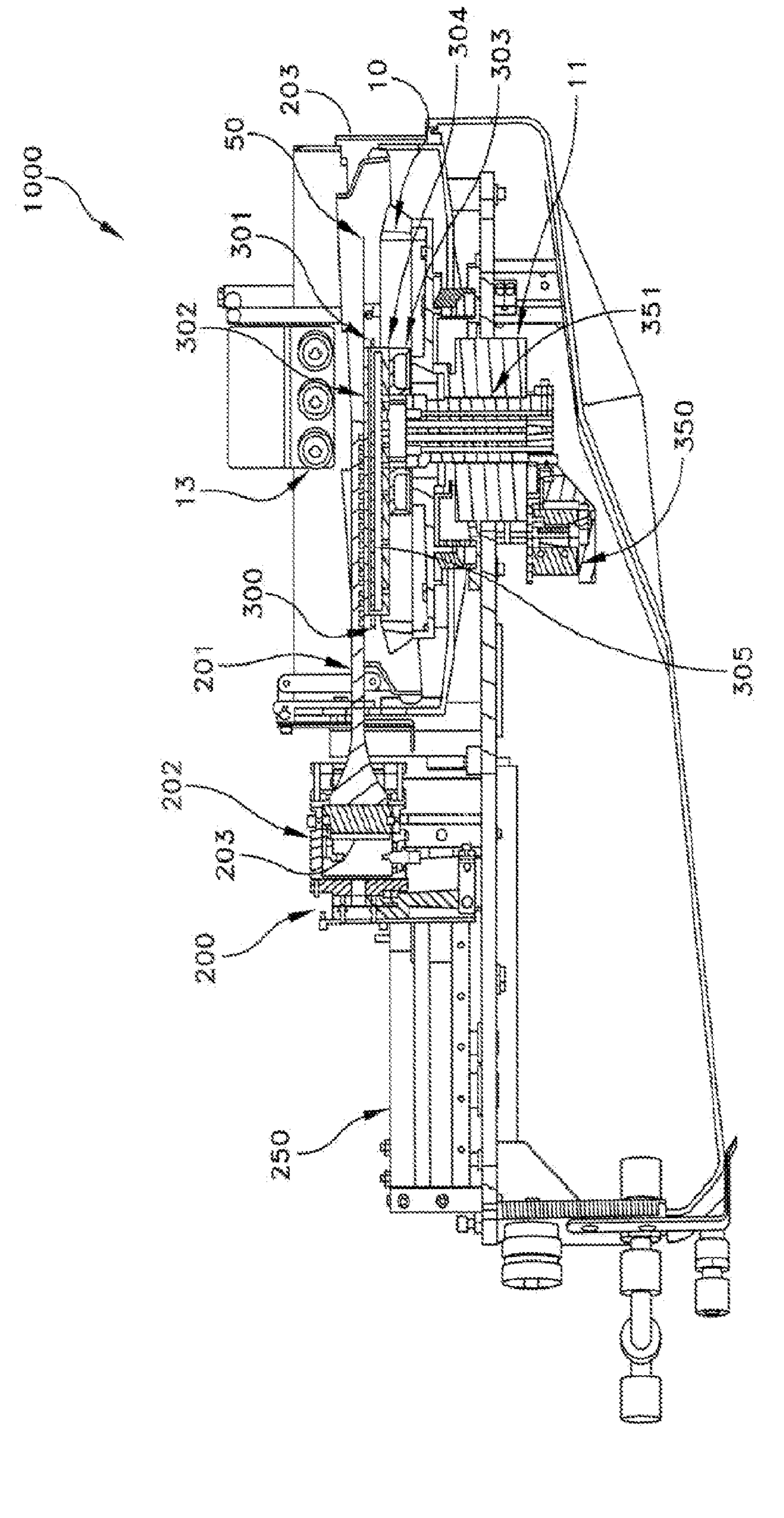


Figure 2


1000
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305
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203
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250

Figure 3

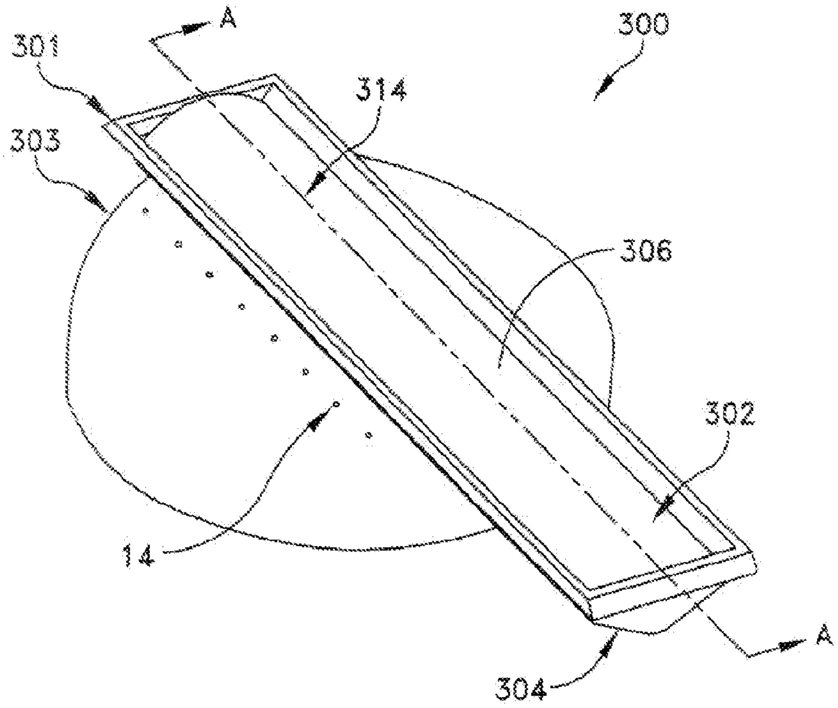

Figure 4

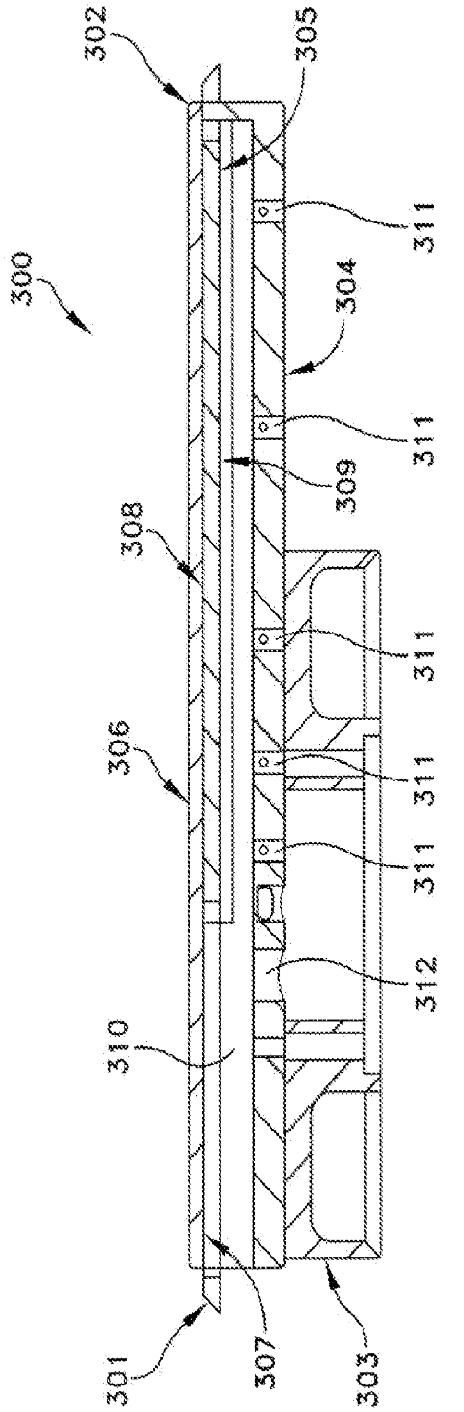
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Figure 5

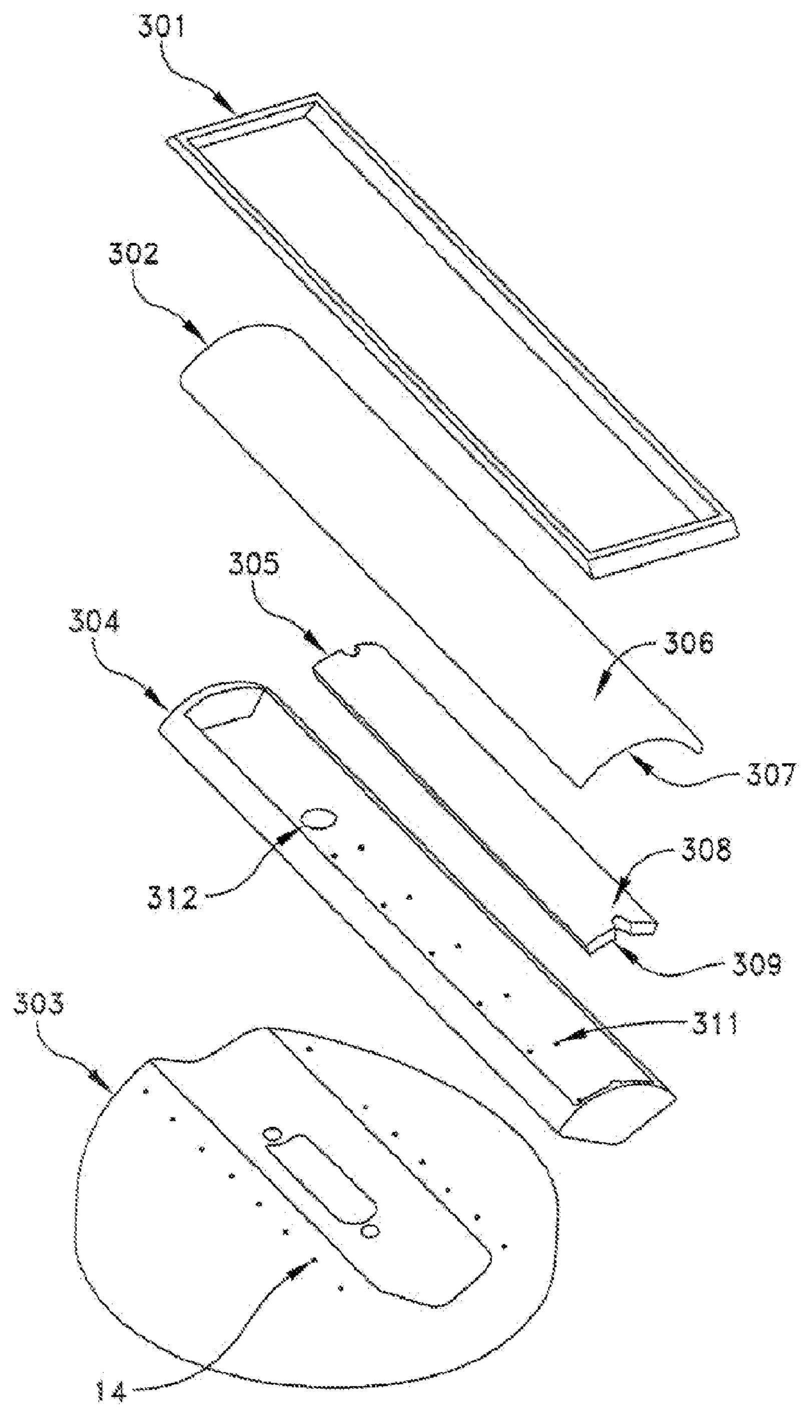
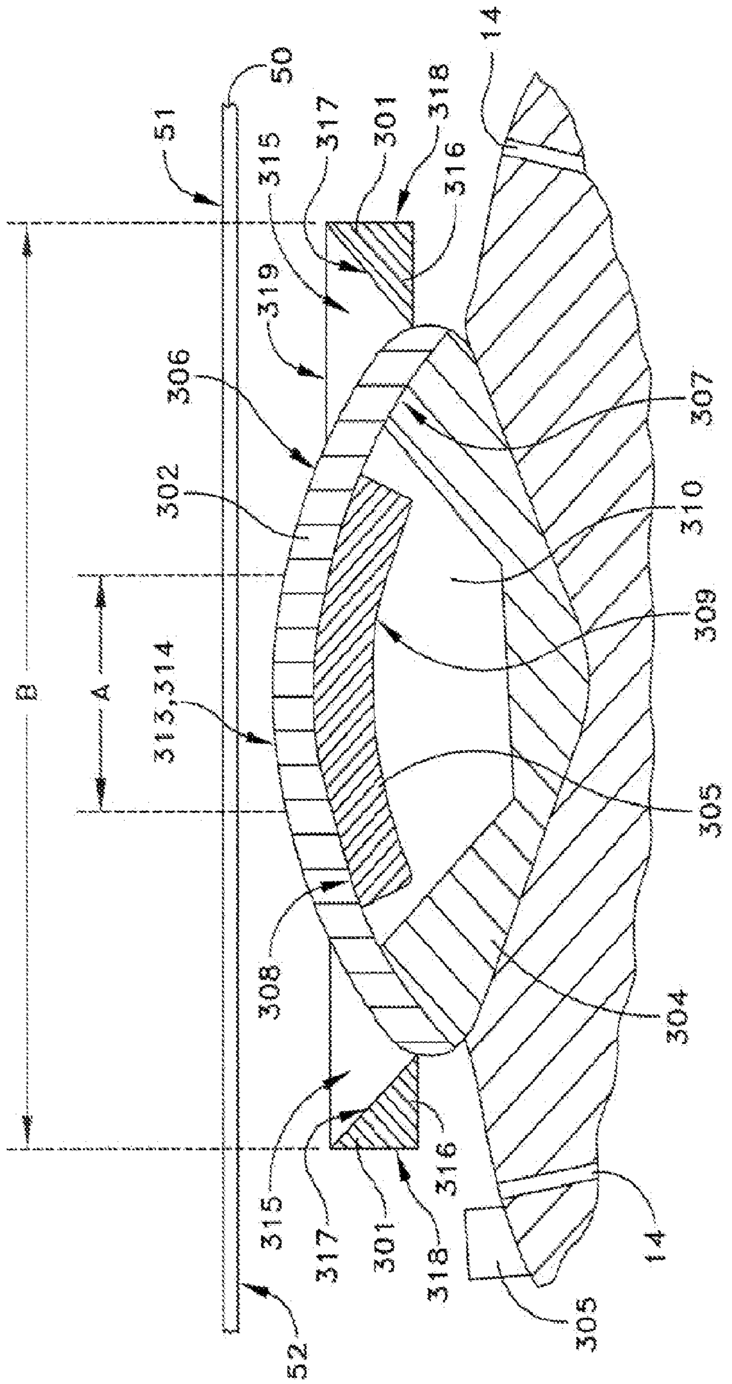


Figure 6


50
51
52
14
315
317
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318
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319
306
307
302
310
309
305
304
308
313,314
A
B

Figure 7

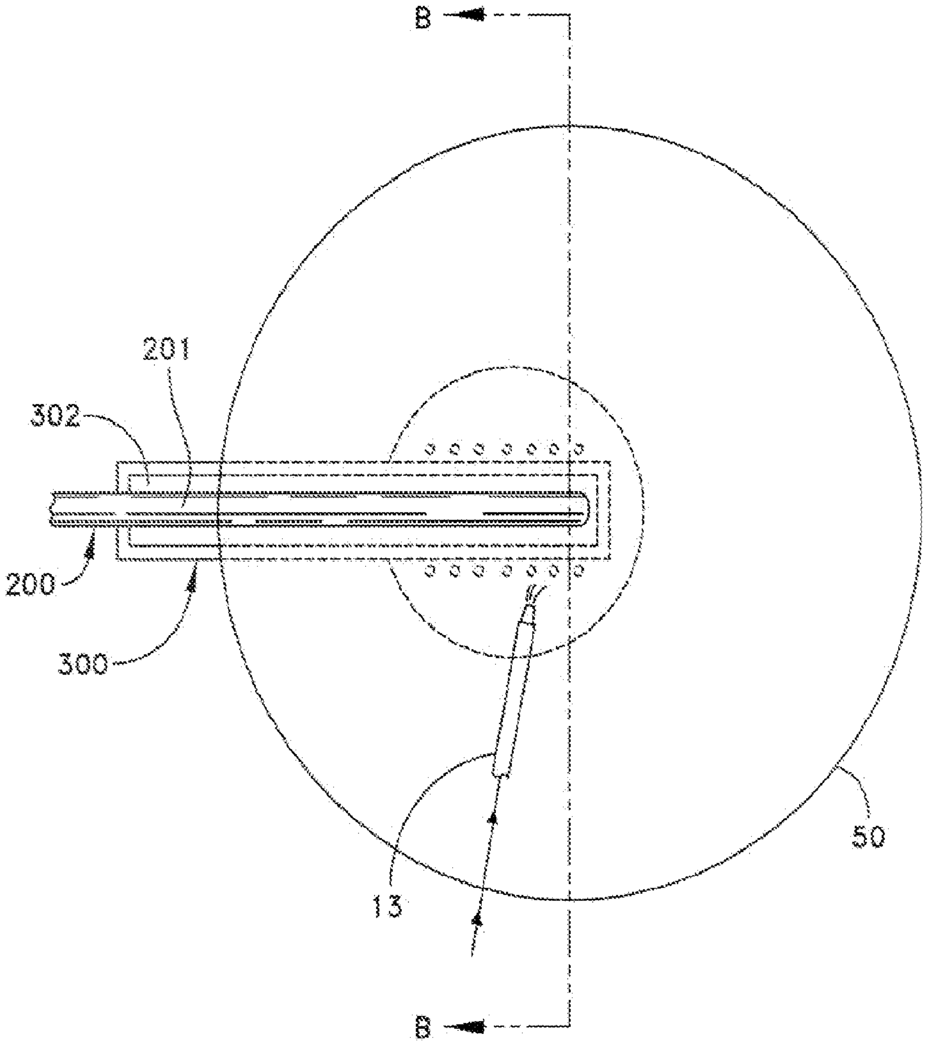


Figure 8

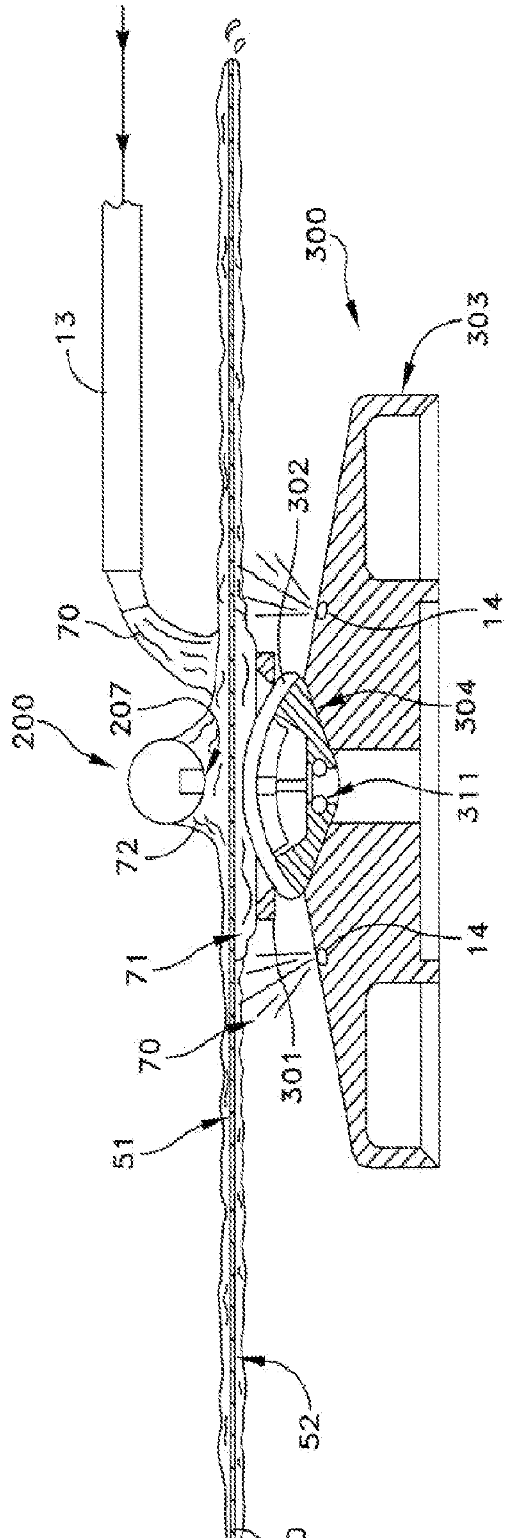


Figure 9

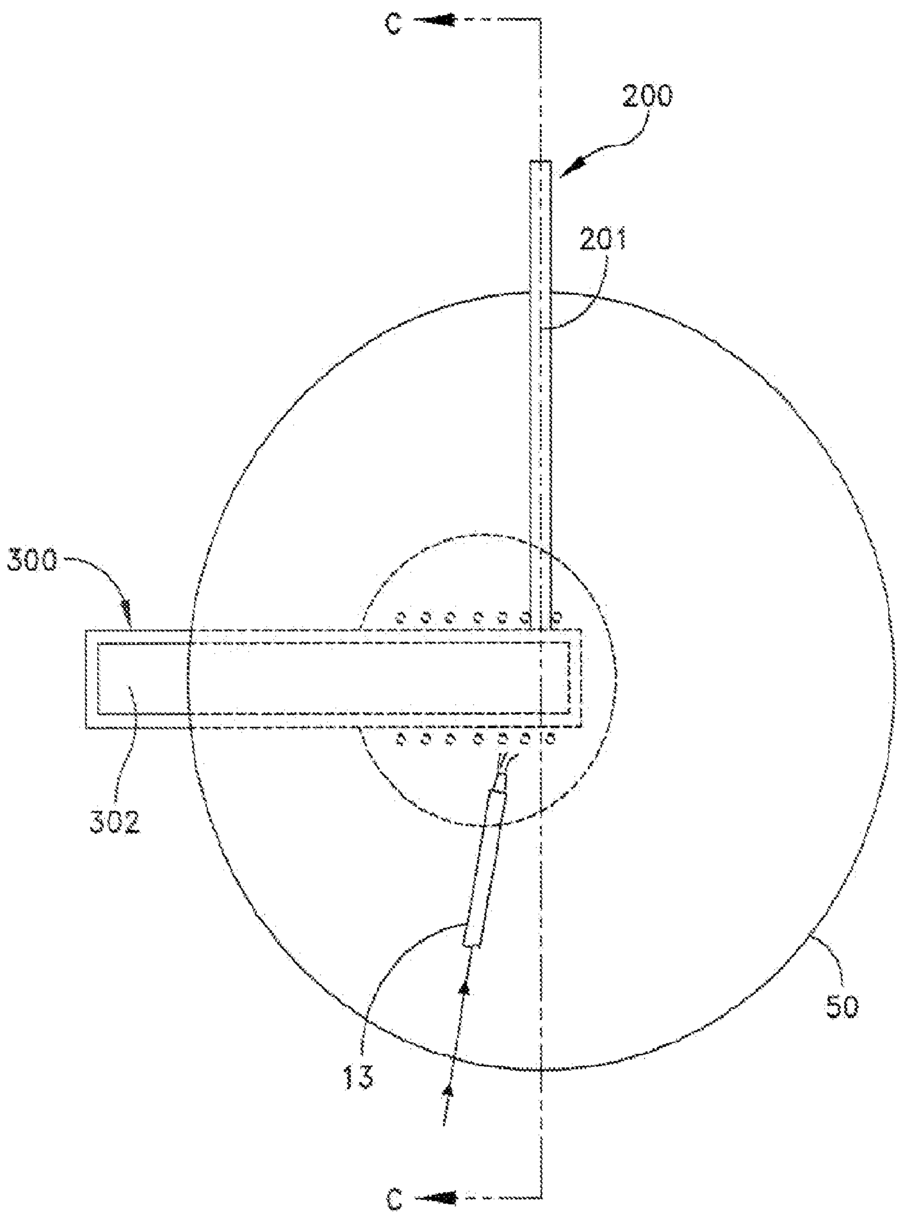


Figure 10

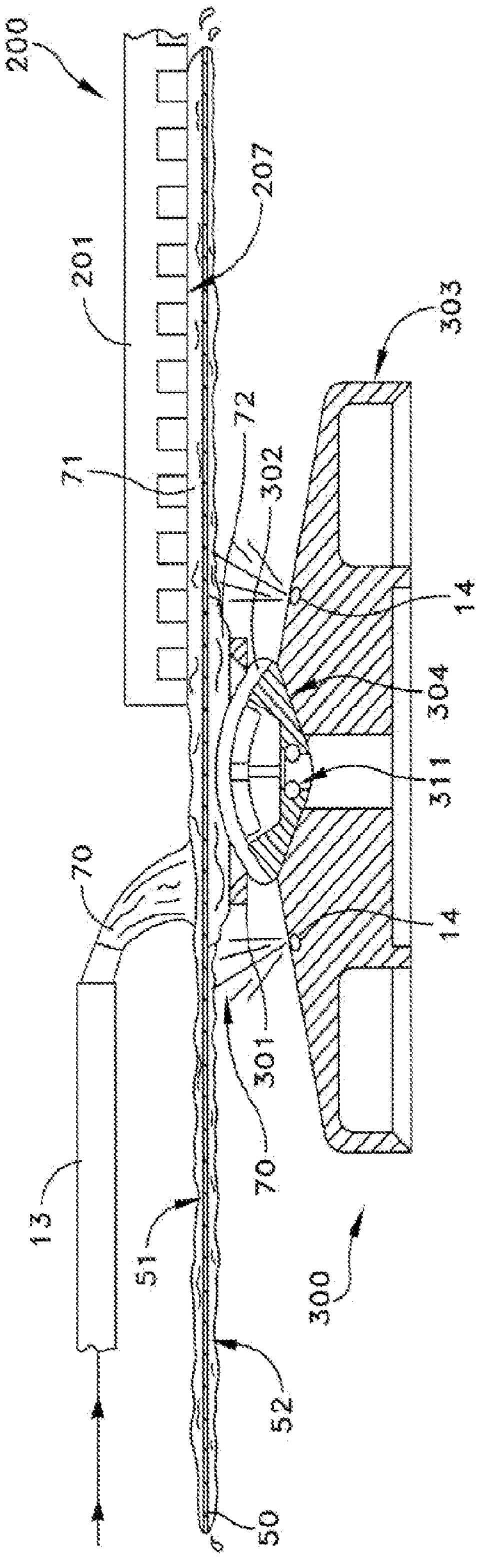


Figure 11

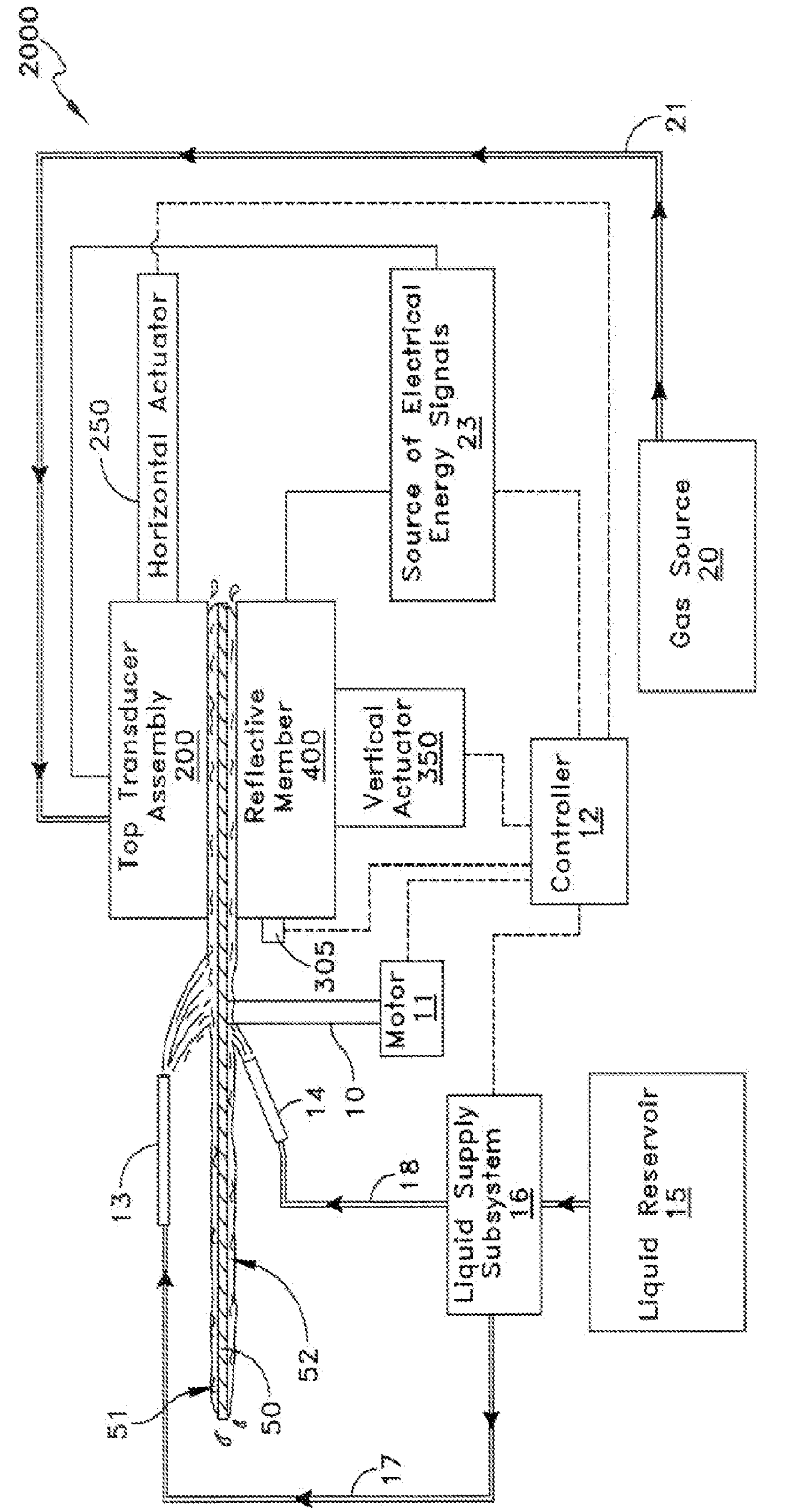
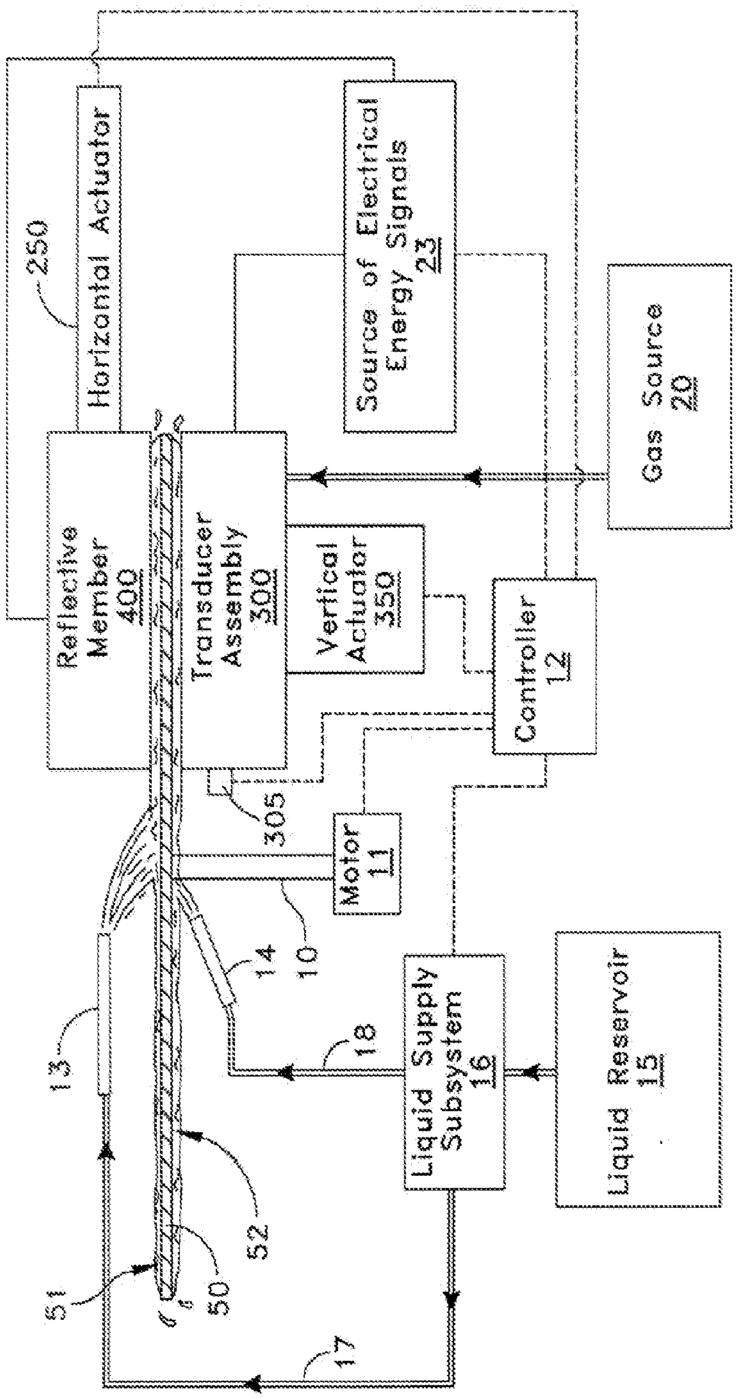

2000
21
250
Horizontal Actuator
Source of Electrical Energy Signals 23
Gas Source 20
Top Transducer Assembly 200
Reflective Member 400
Vertical Actuator 350
Controller 12
305
Motor 11
10
14
13
18
Liquid Supply Subsystem 16
Liquid Reservoir 15
52
50
51
17

Figure 12



Horizontal Actuator
250
Source of Electrical Energy Signals 23
Gas Source 20
Reflective Member 400
Transducer Assembly 300
Vertical Actuator 350
Controller 12
305
Motor 11
10
14
13
18
Liquid Supply Subsystem 16
Liquid Reservoir 15
51
50
52
17

Figure 13

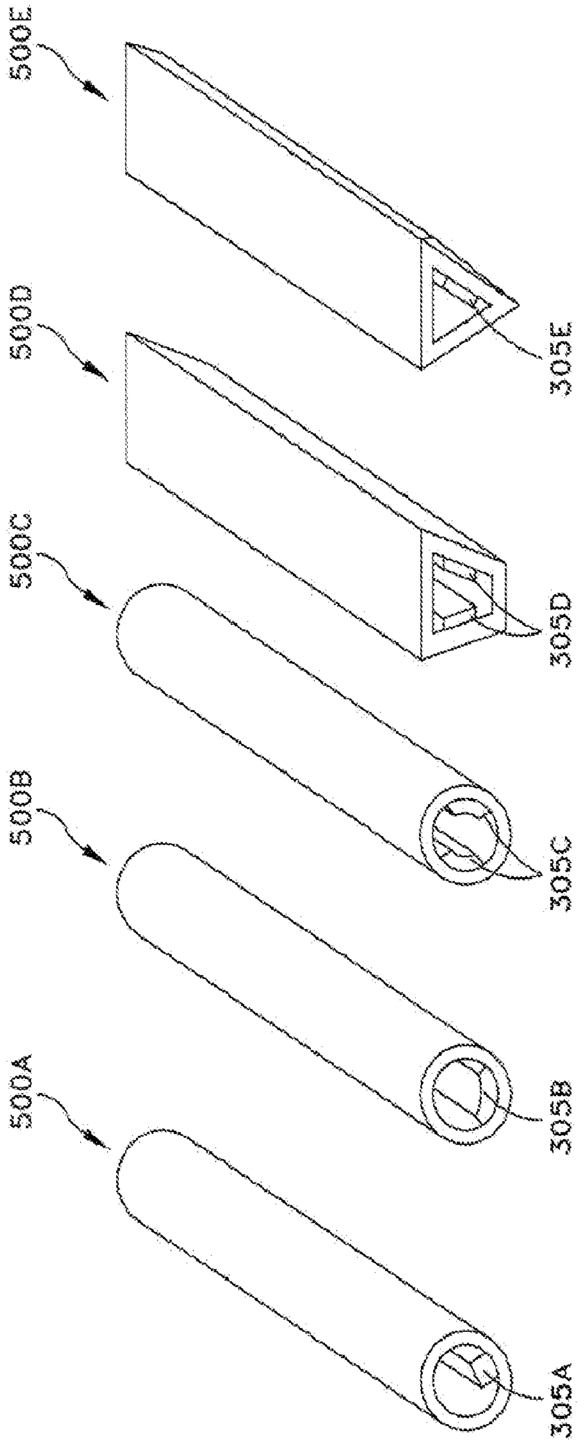


Figure 14