Aug. 3, 1965 D. J. WILLIAMS 3,198,006

RECORDING OF FREENESS OF PAPER MAKING STOCK

Filed Aug. 2, 1962 6 Sheets-Sheet 1

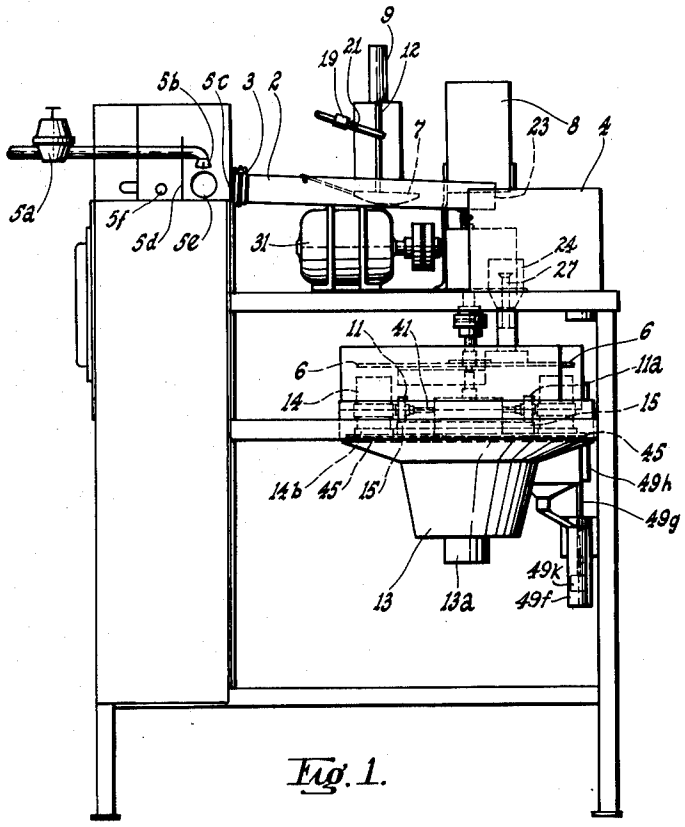


Fig. 1.

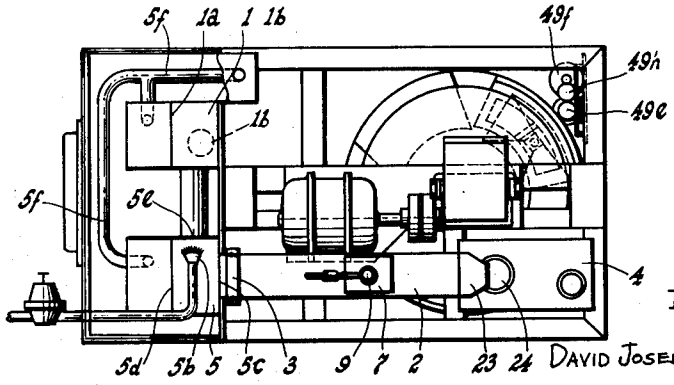


Fig. 2.

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RECORDING OF FREENESS OF PAPER MAKING STOCK

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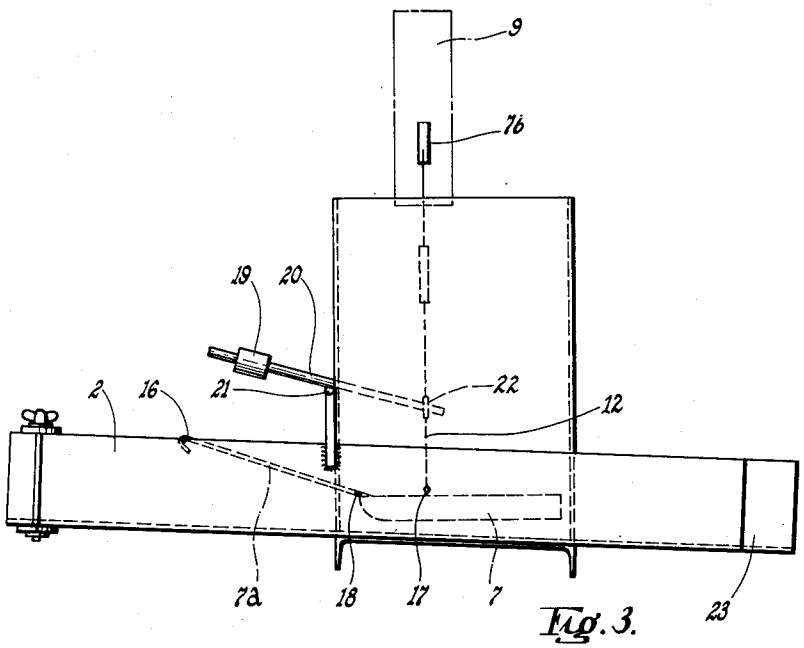


Fig. 3.

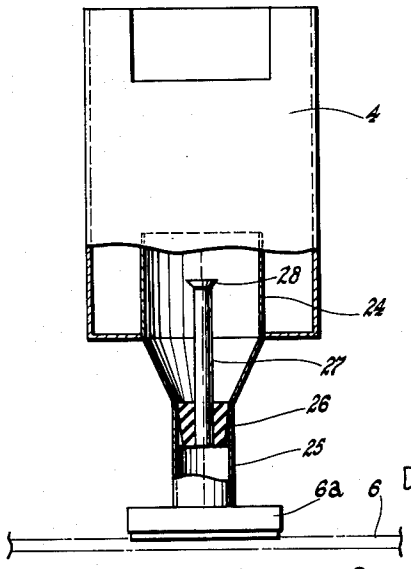


Fig. 4.

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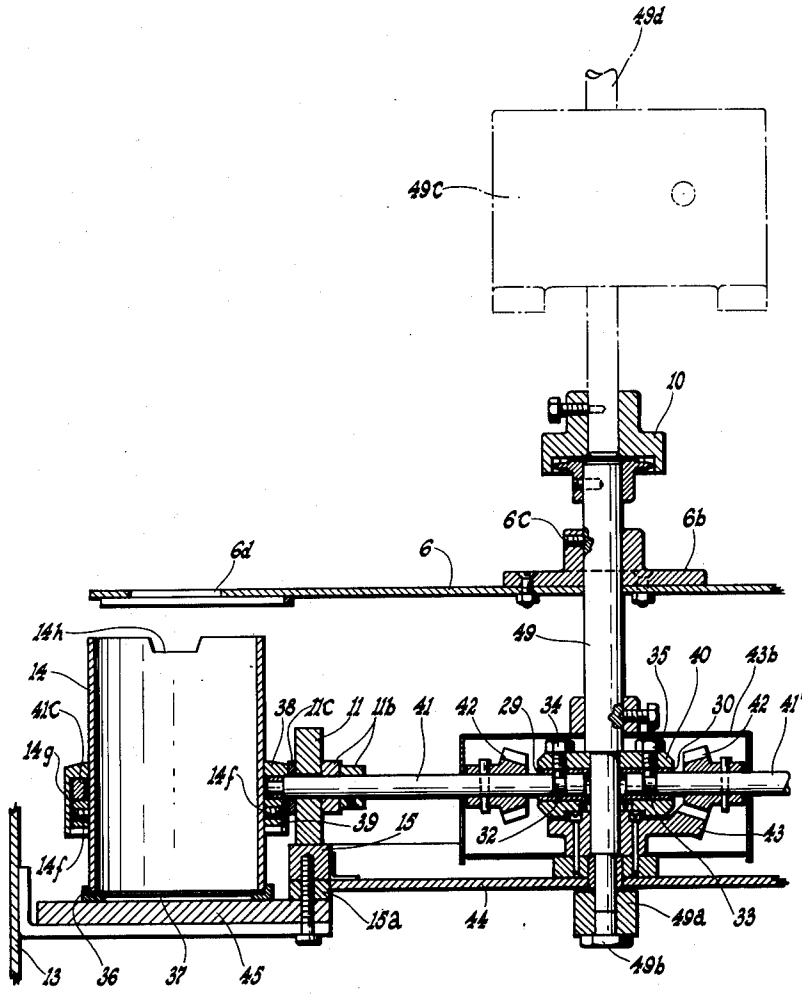


Fig. 5.

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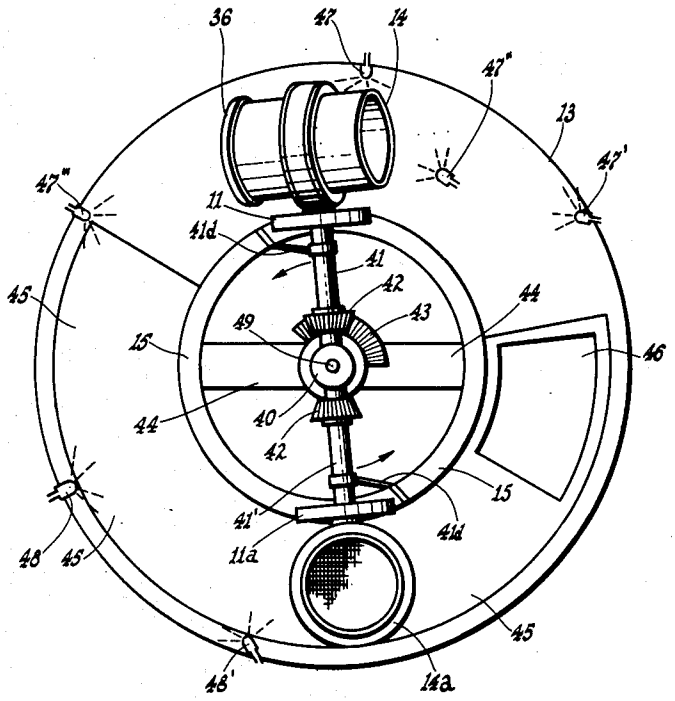


Fig. 6.

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RECORDING OF FREENESS OF PAPER MAKING STOCK

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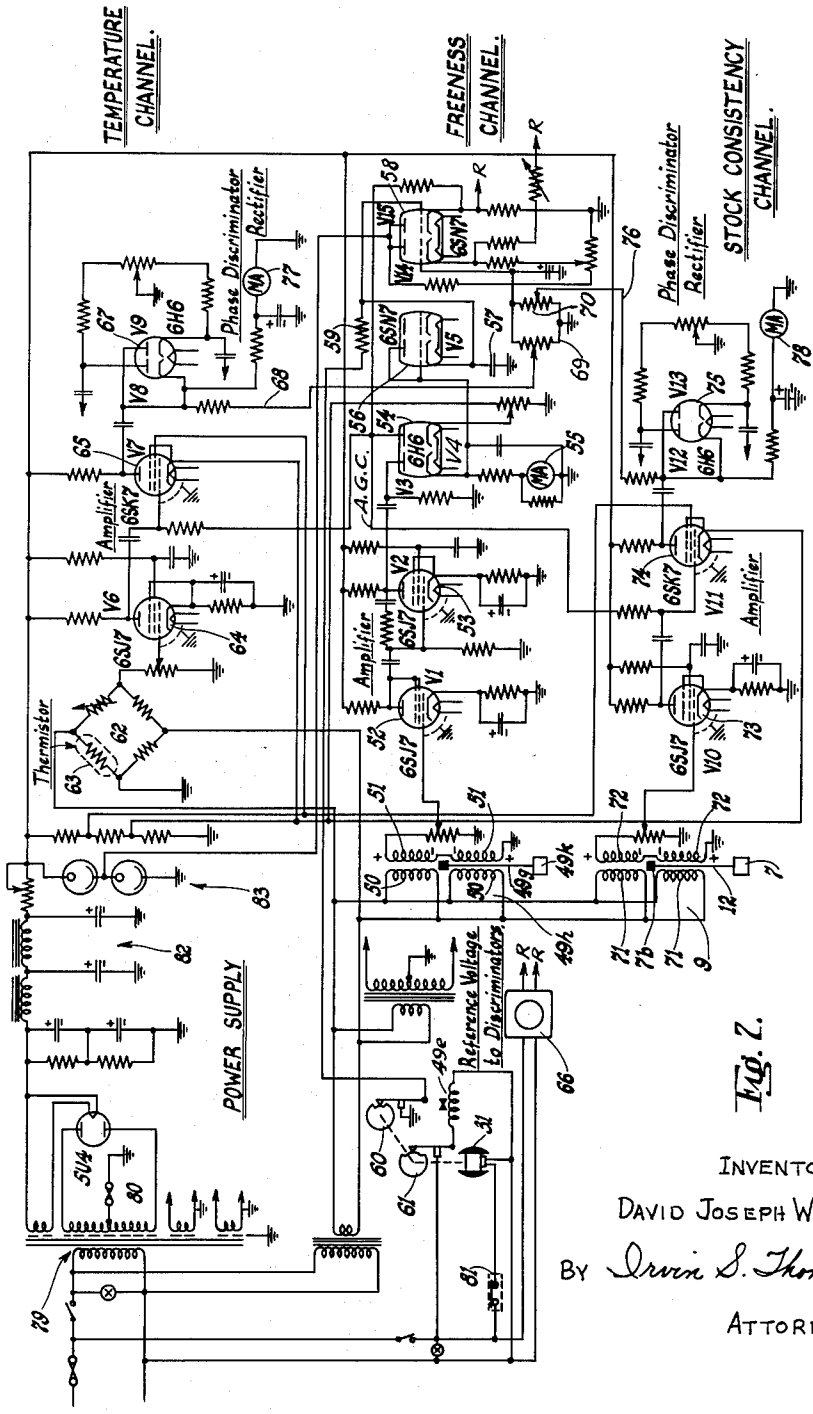


Fig. 7.

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RECORDING OF FREENESS OF PAPER MAKING STOCK

Filed Aug. 2, 1962 6 Sheets-Sheet 6

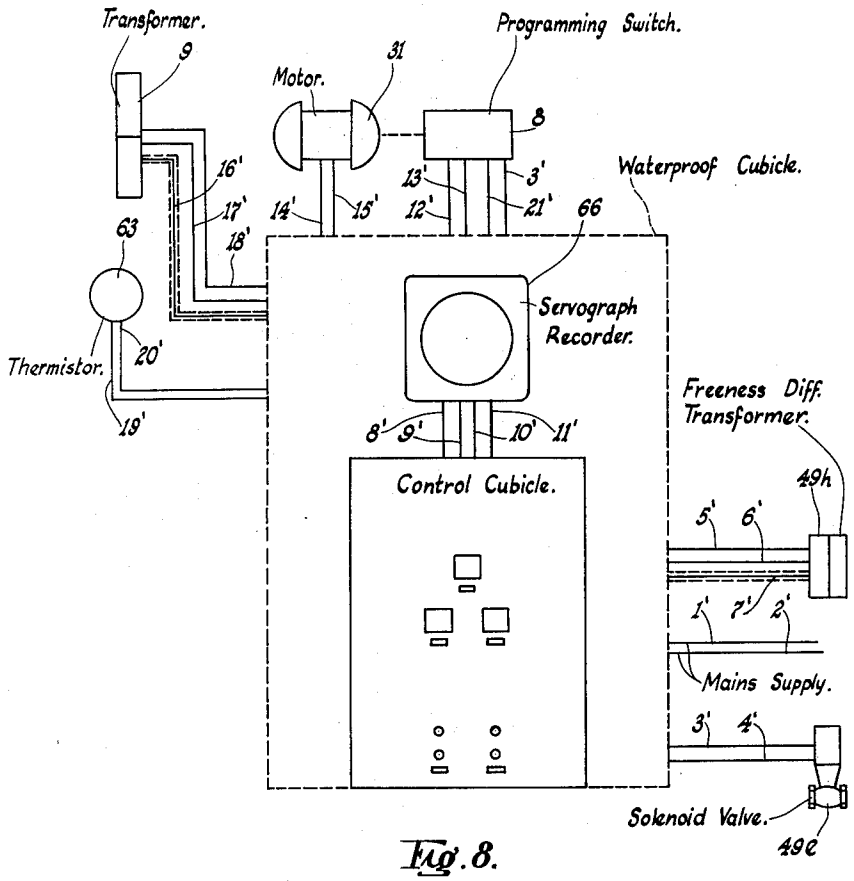


Fig. 8.

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United States Patent Office 3,198,006 Patented Aug. 3, 1965

3,198,006

RECORDING OF FREENESS OF PAPER MAKING STOCK

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Claims priority, application Australia, Feb. 21, 1958, 35,503/58
5 Claims. (Cl. 73—63)

This invention relates to recording the freeness of paper making stock. The application is a continuation-in-part of my application Serial No. 793,517, filed February 16, 1959, now abandoned.

In the past, such measurements have usually necessitated a series of tests carried out periodically by hand. It is well known, however, that manual investigation is subject to substantial errors occurring wherever the human element is involved, in addition to occupying a great deal of time. Certain types of automatic recorders have been known or used but many of these have serious disadvantages. Many, for example, require a constant pulp temperature and consistency which are difficult to realize in practice. Various forms of recorders have been devised which seek to obtain a freeness value by measuring the conductivity and/or dielectric constant of the pulp. This method, however, often suffers inter alia, from the disadvantages of the non-uniform pulp distribution in the measuring zone.

It is the primary object of this invention to provide improved apparatus for accurately and conveniently measuring and recording the freeness of paper making stock while obviating or substantially reducing the disadvantages inherent in freeness recording devices known and used hitherto, and without interfering with normal operations of the paper making machine.

The above and other objects and advantages will become apparent from the following description with reference to the accompanying drawings which relate to a preferred form of the invention, it being understood that the invention is not limited to the precise arrangement shown.

In the drawings:

FIGURE 1 shows in section the general arrangement of a preferred apparatus in accordance with the invention for continuously recording the freeness of paper making stock;

FIGURE 2 is a plan view of the apparatus illustrated in FIGURE 1;

FIGURE 3 is an enlarged section of part of the apparatus illustrated in FIGURES 1 and 2, and shows an arrangement for sensing the stock concentration;

FIGURE 4 is an enlarged section of part of the apparatus illustrated in FIGURES 1 and 2, and shows a container for receiving stock;

FIGURE 5 shows details of part of the freeness-testing section of the apparatus illustrated in FIGURES 1 and 2;

FIGURE 6 is a plan view of the freeness testing section shown in part in FIGURE 5;

FIGURE 7 is a circuit diagram showing a preferred electrical system for use in connection with the apparatus of FIGURES 1 to 6, and

FIGURE 8 is a schematic layout showing in diagrammatic form the relationship between certain components of the apparatus illustrated in FIGURES 1 to 6.

PULP DILUTION AND DELIVERY SYSTEM

Referring more particularly to FIGURES 1 to 4, the pulp supplied, for example, from a head box and through a flexible hose (not shown) is fed to feeding tank **1** which preferably incorporates a constant head device such as a weir **1***a* from which the overflow may be redirected to the machine chest. From feeding tank **1**, stock is supplied to dilution tank **5** where it is diluted to approximately 0.8% concentration with water supplied through a reducing valve **5***a* which is advantageously set to a pressure of the order of 15 lbs. per square inch. The diluting water may pass into tank **5** through a fish-tail jet **5***b* applied across outlet **5***e* from tank **1** to ensure thorough mixing.

Dilution tank **5** may also be provided with a weir such as shown at **5***d* to give a constant head under which the diluted pulp discharges through orifice **5***c* to the delivery channel **2** which preferably has a slight inclination downwardly in a direction away from orifice **5***c* towards its outlet end **23**. Overflow from weir **5***d* may also be directed into a common overflow conduit **5***f* leading, for example, back to the machine chest (not shown). Delivery channel **2** may be fixed to the orifice **5***c* of dilution tank **5**, for example by means of clamping plates **3**, and a seal may be effected if desired by using a rubber or like insert between channel **2** and orifice **5***c*. In addition, baffle means, such as a "triple plate" baffle may be situated at the orifice **5***c* to minimize flow pulsations along the delivery channel **2**.

Referring more particularly to FIGURE 3, stock concentration variations (viz. variations in the concentration of oven-dry fibre per given quantity of fluid) are sensed by electronically detecting the rise and fall of a float **7** mounted in delivery channel **2** for example by means of a rod or rods **7***a* pivotally mounted at one end on a pin **16** fixed relatively to channel **2** and at the other end to an appropriate bracket **18** attached to float **7**. The float also has attached to it, preferably by means of a pivoted connection **17**, an upstanding rod **12**, preferably of copper, constrained to move substantially vertically, i.e. in the direction of its length, and having affixed to its upper end an armature or slug **7***b* (e.g. a length of mild steel), movement of which modifies the induced voltage in the windings of a differential transformer denoted generally by **9** and described more fully hereinafter with reference to FIGURE 7. The movement of float **7** and its associated rod **12** and slug **7***b* may be stabilized and regulated by means of counterweight **19** fixed to lever **20** pivoted at **21** and passing through an aperture **22** in rod **12**.

Stock passes from the outlet end **23** of delivery channel **2** into container **24** situated in tank **4** (see FIGURE 4). Container **24** advantageously holds approximately 600 mil. of stock which, together with the quantity of stock flowing into freeness vessel **14**, **14***a* (to be described more fully hereinafter) while the rotary valve **6** is open, provides a test quantity of stock just in excess of the volume of the freeness vessel. The discharge from container **24** is via an outlet **25** in which may be inserted a stopper **26** of rubber or like material adapted to hold a length of tube **27**, and it will be evident that the posi-

tioning of tube 27 and consequent adjustment of the top 28 thereof permits of a fine degree of control over the total volume of stock discharged into the freeness vessel, thus avoiding excessive overflow. Outlet 25 may be sealed against rotary valve 6 by gasket 6a, preferably of foamed isocyanate plastic material.

Stock falling into container 24 from the delivery channel 2 has the desirable effect of agitating stock awaiting discharge to the freeness vessel. Overflow from container 24 may be passed into the common return system associated with conduit 5f, thence to be lead back to the machine chest.

FREENESS TESTING SECTION

Referring more particularly to FIGURES 5 and 6, the freeness testing section of the unit includes a vertical main drive shaft 49 driven preferably through a reduction gear box 49c from motor 31 at a speed preferably of the order of about 1 revolution per minute. To shaft 49 there may be fixed a spacing block 40 of bronze or other suitable material and into which two bronze or like bushings 29, 30 are sweated to provide diametrically opposite bearings for two independent horizontal freeness vessel supporting shafts 41, 41', advantageously of stainless steel. Each of shafts 41, 41' has a recess 32, 33 respectively by which the lateral position of the shaft may be fixed by means of set screws 34, 35 respectively, adjustable from the top of spacing block 40 so that they protrude through bushings 29, 30 to locate their respective shafts 41, 41'.

The two freeness vessels are denoted generally by 14, 14a and may be formed from bronze tubing. Each is advantageously of about 1 litre capacity and has a threaded bottom portion adapted to receive a wear-resistant retaining ring 36 which is arranged to hold in position a "Canadian" standard freeness draining plate 37.

Two collars 38, 39 may be fitted to each vessel one (38) above, and the other (39), below a driving ring 41c attached to supporting shaft 41 to hold the freeness vessel in position relatively to driving ring 41c while undergoing a washing stage in which the vessel is unsupported by the base track element 45, a preferred form of which is described hereinafter. Collars 38, 39 are of sufficiently large internal diameter to slide over the vessels 14, 14a to which they are held, for example, by grub screws 14f.

The upper collar 38 has a skirt 14g of a diameter greater than the external diameter of driving ring 41c. This skirt forms a canopy to prevent plup from accumulating around the driving ring. The necessary freedom of movement of the vessel about the driving ring is thereby maintained. As the driving ring 41c engages the skirt 14g, the vessel is pulled rather than pushed and this is an important factor in reducing vibration or "judder." A section 14h may be cut from the top rear edge of each vessel to divert overflow to the gear.

A pinion 42 is fixed on each vessel supporting shaft 41, 41' near the spacing block 40, and as the vertical main drive shaft 49 is rotated, the stage is reached where pinion 42 is caused to engage geared sector 43 fixed to the base support (indicated generally by 43a) of the freeness vessel assembly. In this manner, each vessel 14, 14a may be completely rotated at the appropriate stage about an axis parallel to its supporting shaft for receipt of stock samples, for discharge of the samples, and for cleaning.

Each vessel supporting shaft 41 is advantageously fitted with a loose roller 11, 11a adapted to run on ring 15 which is preferably of bronze. Fitted substantially diametrally beneath ring 15 is a bearing support strap 44 in the centre of which is mounted the geared sector 43 and the supporting block 40. Upward movement of shaft 49 may be prevented by a sleeve 49a or the like member placed between the bottom of the bearing support strap 44 and the head of a retaining bolt 49b which may be screwed into the bottom end of the vertical main drive shaft 49. The top of shaft 49 may be coupled to an output shaft of the reduction gear box 49c through a flexible coupling 10.

The rotary valve 6 which is mounted on the vertical main drive shaft 49 just above the vessels 14, 14a is preferably an aluminium disc having apertures 6d so located that each is immediately above one of the freeness vessels. A bronze flange 6b may be bolted to the centre of this disc and may be suitably bored for fitting onto the vertical main drive shaft 49 upon which its position may be maintained by means of grub screw 6c.

The base track element 45 is preferably of ground and polished stainless steel over which the vessels are driven for approximately 240° of each cycle. The track element 45 may be bolted to the bottom of ring 15 by means of spacers 15a of bronze or other suitable material, which spacers provide a gap for spray water and any excess pulp to pass through the drainage system beneath the vessels. The exposed part of track element 45 forms a seal with retaining ring 36 on the bottom of each vessel for substantially 180° of the cycle. Following this section, the track element 45 is cut away to form an aperture 46 for approximately 40° so that the pulp may drain freely while the vessel passes over this aperture, the drainage period being approximately 10 seconds.

The fixed geared sector 43 is preferably placed so that when the vessel leaves the drainage section, sector 43 is engaged by pinion 42 on the supporting shaft 41, the shaft being thus caused to rotate to such an extent as will invert the vessel 14 thus discharging the tested sample, and after the vessel 14 has passed over suitably located washing sprays 47', 47'', 47''', to return it to this former upright position. Vessel 14 then slides onto the base track element 45 and the pinion 42 and geared sector 43 disengage. It will be evident that loose rollers 11, 11a adapted to run on ring 15 reduce the load on the vessel supporting shaft bearings 29, 30 when pinion 42 and geared sector 43 are engaged and the vessel is unsupported by track element 45. Rollers 11, 11a may be held in position by any suitable means, for example by appropriately located rollers 11b, 11c.

In addition, rubber bladed sweepers 41d may be pivotally mounted on the vessel supporting shafts 41 to ride on ring 15 ahead of the rollers and to deflect any accumulated pulp into the drainage system.

The entire apparatus may be levelled and bolted in three positions to the side of a stepped cone 13 which is preferably of stainless steel. The receptacle for the drainage water may be fitted into the step of the cone and the tested stock, spillage and spray water may pass into the centre to drain via the outlet 13a at the centre of the lower section.

Pinions 42 and geared sector 43 may, if desired, be protected from spray water by a cylindrical cover 43b for example of galvanized iron and situated adjacent the main drive shaft 49.

Spouts or nozzles 47, 48 for providing jets of water, preferably in the form of "fishtail" sprays, are advantageously situated at intervals around the track 45. One jet 47' may be so arranged that it directs water onto the bottom of the freeness plate 37 when the vessel commences to invert. A second jet 47'' is preferably placed at approximately 70° to the horizontal and in the direction of travel so as to spray into the vessel when the last mentioned is inverted and a similar function is performed by the third jet 47. A fourth jet 47''' sprays the track at the point where the vessel first meets it, while the fifth and sixth jets 48 and 48' direct their jets over the track, the jet 48' being placed just after the filling point and directing its jet along the track against the direction of rotation to disperse any overflow from the vessel.

A vertical shaft 49d from the reduction gear box 49c may be extended via a flexible coupling to actuate microswitches 60, 61 (FIGURE 7) or like timing means controlling the sequence of operations. This programming section may be housed to advantage in a metal housing

such as shown at **8**, preferably supported on the framework of the apparatus.

TIMING OF THE INSTRUMENT

Referring now also to FIGURES 7 and 8, the timing for a two-vessel (**14**, **14***a*) system may be established so that during each 60-second interval of rotation of the vertical main drive shaft **49**, both vessels are filled, the cumulative drainage rate registered and the vessels rotated through 360° about axes parallel to their supporting shafts for washing purposes.

Taking the beginning of the drainage period of vessel **14** as the commencement of the cycle, solenoid valve **49***e* which empties measuring tank **49***f* is set to close just as the leading edge of the vessel reaches the drainage testing section. It remains closed until approximately the 51st second while the drainage water from both vessels accumulates in measuring tank **49***f* and raises a float **49***k* attached to the lower end of longitudinally slidable rod **49***g* projecting into differential transformer **49***h* whereby the water level in measuring tank **49***f* is sensed. The solenoid valve **49***e* then opens until the 60th second to allow the drainage water to flow from measuring tank **49***f*.

To meet this requirement, the solenoid valve may be operated by a 54° cam segment of microswitch **61** set to start at 306° in the 360° cycle.

The combination of valves V_5 and V_{15} together with the 8-microfarad storage capacitor **57** between the cathode V_5 and ground supplies to recorder **66** a voltage proportional to the mean peak value of the tests. The response to any increase in freeness is immediate, but downward response is normally limited by the rate of discharge of storage capacitor **57**. This is compensated for by a second cam-operated microswitch **60** arranged to connect a bleed resistor **59** across the storage capacitor **57** when every peak value is reached during the 49th and 50th seconds of the cycle, so that in the event of a reduced freeness, capacitor **57** is permitted to discharge rapidly to the new value.

The cam of microswitch **60** preferably has one 12° segment which is suitably located to operate over the 294° to 306° sector of the cycle. All switches preferably have contacts connected in parallel for the sake of reliability.

DESCRIPTION OF CIRCUIT

(i) *Freeness measurement*

A preferred form of differential transformer used for the purpose of this invention may consist of two substantially identical sections placed side-by-side. Each section may have about 5,000 turns, for example of 0.0075 double tough enamel-covered wire on both primary and secondary windings. The formers may be turned from ten-inch lengths of polystyrene rod, preferably of about two inches in diameter, to a diameter of one inch. Flanges of 3/16 of an inch may be left at the ends. Each former preferably has an axial bore along its entire length. In one of the formers, the bore receives a rod attached to the float in delivery channel **2** or measuring tank **49***f*, as the case may be, while in the other former, the bore accommodates any balancing slugs which may be necessary. These transformers may be evenly wound. The primary windings of each section are preferably connected in parallel, the secondary windings being series opposed.

The differential transformer associated with, and located above, measuring tank **49***f* is denoted generally by **49***h* and includes primary and secondary windings **50** and **51** respectively. The output voltage from transformer **49***h*, modified by changes in position of rod **49***g* therewith, is applied to an amplifier associated with the freeness channel. Then amplifier includes a pentode **52** 6SJ7 (V_1) feeding pentode **53** 6SJ7(V_2) which in turn feeds metering diode **54** ½-6H6(V_3), the rectified current of which is measured by a 50-microamp meter **55** in the cathode circuit. The D.C. voltage at the cathode of **54** is applied to the transient peak volt meter triode **56** (V_5) (½6SN7) through which the eight microfarad (preferably paper) condenser **57** is charged to a peak value representing the volume arising from the measurement of each test sample. The voltage of this condenser is applied to the control grid of one section of the differential metering amplifier **58** formed by V_{14} and V_{15} (6SN7). With zero input, the cathode currents through **58** (V_{14} and V_{15}) are balanced by the variable bias control. In this condition both cathodes are at the same potential above ground. When a voltage appears at the grid of V_{15} its cathode current increases and the potential difference which then exists between the cathodes is measured and recorded in recorder **66** and the series resistance of 150,000 ohms of which 100,000 ohms is variable. The bleed resistance **59** in the circuitry associated with the transient peak volt meter charging capacitor **57** is such that a decay of approximately 2% of the voltage to which it is charged occurs during the period of one minute between tests. As this imposes a considerable limitation on the speed of downward response of the voltmeter, programming microswitch **60** on the extended vertical shaft **49***d* connects the shunt resistance **59**, preferably of about 10 megohms, across the capacitor when the peak value of each test is reached. In this way the overall discharge rate is not materially affected but the instrument is able to follow a downward trend almost as quickly as an upward trend. It is most important that the lead from capacitor **57** to microswitch **60** be of high insulator resistance.

(ii) *Temperature correction*

The temperature measuring channel includes a thermistor bridge, denoted generally by **62** including thermistor **63** (e.g. of the "Stantel" type) in which temperature variation is detected by a change in resistance. The bridge unbalance thus brought about is amplified by a two stage amplifier, one stage **64** 6SJ7(V_6) feeding another **65** 6SK7(V_7). The output from the latter stage V_7 feeds a phase-discriminating rectifier **67** (V_8 and V_9) comprising a dual-diode arrangement such as 6H6, from which is derived either a positive or negative D.C. voltage of amplitude and polarity dependent on the magnitude and direction of the temperature variation.

This D.C. voltage is then applied in an appropriate proportion through lead **68** to the grid circuit of tube **58** (V_{14} and V_{15}), as selected by adjusting the temperature correction potentiometer **69**. It then causes the cathode current of section V_{14} to vary and so adds to, or subtracts from, the potential difference existing between the cathodes of V_{14} and V_{15} of tube **58** due to the freeness value.

(iii) *Stock concentration correction*

The stock concentration measuring section includes a differential transformer denoted generally by **9** (FIGS. 1, 2 and 3) including primary and secondary windings **71** and **72** respectively. The voltage induced in differential transformer **9** is modified by the rise and fall of float **7** with its associated rod **12** and slug **7***b*. The rod **12** is preferably located midway between the two sections of the transformer at the desired stock concentration. Under these conditions the voltages in both secondary windings **72** balance, and there is no output.

As float **7** rises or falls with stock concentration variation, an "unbalance" voltage is induced and is applied to a stock concentration channel amplifier including tubes **73** and **74** similar to that used in the temperature channel, with the output from **74** being applied to the phase discriminating rectifier **75** formed by V_{12} and V_{13} (6H6) by which means a positive or negative D.C. voltage is similarly derived. This voltage is also applied, through lead **76**, in an appropriate proportion as selected by the "S/C Correction" potentiometer **70**, to the grid circuit of section V_{14} of tube **58**. It then similarly causes the cathode current of section V_{14} to vary and so adds to, or

subtracts from, the potential difference existing between the cathodes of V_{14} and V_{15} due to the freeness value.

These correction controls are advantageously in parallel in the grid circuit of section V_{14}, and the corrections for temperature and stock concentration variation may oppose or assist as required by the circumstances.

The gain of the second stages of the stock concentration and temperature channels is automatically controlled by the output of the freeness channel as derived from the cathode of V_{15}. A higher freeness increases the gain of these channels and maintains any correction voltage in the appropriate proportion. As the correction characteristic for stock concentration, which is by far the most frequent variable, flattens at a freeness corresponding to approximately 400 Canadian Standard freeness, a diode (V_4) is connected from the automatic gain control line to ground and biased so that it bypasses any automatic gain control voltage above that corresponding to a freeness of 400 Canadian Standard freeness.

Temperature and stock concentration variations are indicated separately on 25–0–25 microamp meters 77 and 78 respectively, in their respective discriminator circuits 67 and 75.

(iv) *Power supply*

All three bridge circuits may be supplied from a common 6.3 volt 50-cycle supply, and the reference voltage for the discriminators derived, for example, from a $^{125}/_{10000}$ ohm line-transformer 79, the secondary 80 of which is centre-tapped and grounded.

The main drive motor 31 is advantageously a half-horse power single-phase 1425 r.p.m. totally enclosed unit preferably protected by a Westinghouse Sentinel Thermal Overload 81.

The power supply uses a Trimax TP2246 325 v. per side 150 milliamp transformer 79 and a capacitor input double section filter 82. The output is regulated at about 300 volts by two VR150/30 regulators 83 in series.

The following table refers to the schematic layout illustrated in FIGURE 8, and indicates the duty performed by the most important electrical leads connecting the various components.

SCHEDULE OF WIRE NOS.

Wire Nos.	Duty
1′, 3′, 8′, 14′, 21′	240 v.
2′, 4′, 15′, 19′	Neutral.
12′, 13′	VTVM (low loss) shunt leads to 10 meg.
10′, 11′	L/T. D.C. to Recorder Movement.
5′, 6′, 17′, 16′	6.3 v. A.C.N.

Having now described my invention, what I claim as new and desire to secure by Letters Patent is:

1. Apparatus for continuously recording the freeness of paper making stock comprising a delivery channel for receiving paper making stock diluted with water, sensing means operatively connected to a differential transformer-type measuring means disposed in said delivery channel for sensing variations in the consistency of said paper making stock, a freeness testing assembly disposed adjacent said delivery channel including at least

one vessel member of constant volume operatively connected to a rotating means to rotate said vessel member in a circular path, said vessel member receiving during a portion of said circular path a sample of substantially constant volume of said paper making stock, said vessel member draining during another portion of said circular path the water from said sample of paper making stock, tank means for receiving the drained water, float means operatively connected to a further differential transformer-type measuring means disposed in said tank means for measuring the volume of the drained water, temperature measuring means disposed in said tank means to measure the temperature of the drained water, means connecting said differential means for sensing variations in the consistency of said paper making stock and said temperature measuring means to said further differential means to apply corrections to the measurements of the volume of the drained water to obtain freeness of said paper making stock, and means for recording the freeness of said paper making stock.

2. An apparatus according to claim 1 in which said freeness testing assembly further includes washing means to wash said vessel member during the remaining portion of said circular path, and means operatively connected to said rotating means to invert said vessel member during this remaining portion of said circular path so that said vessel member is thoroughly washed to remove paper making stock therefrom before receiving another sample.

3. An apparatus according to claim 1 in which each of said differential transformer-type measuring means comprises a differential transformer having rod means containing on one end, which is movable within said transformer, slug means to vary the output of said transformer, the other end of said rod means being connected to said sensing means and float means.

4. An apparatus according to claim 1 in which said freeness testing assembly further includes another vessel member, and a track element disposed beneath and on which the bottom of said vessel members ride to form a seal during the portion of said circular path in which said vessel members receive said sample of the paper making stock, said track element having an aperture therein to allow the drainage water to pass into said tank means.

5. An apparatus according to claim 1, and further comprising valve means for emptying said tank means, and programming switch means operatively connected to said rotating means to operate said valve means to periodically drain said tank means after the freeness of a sample therein has been recorded.

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DAVID SCHONBERG, *Examiner.*