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A Distant Reading Electronic Anemometer and a Selsyn Operated Windvane

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ABSTRACT. With the increase in aviation, the requisitions for meteorological reports from aerodromes have also increased appreciably. The data have to be supplied both for the planes in the air and on the ground with the least possible delay. Different types of instruments have been constructed to measure the velocity and direction of surface wind from the room of the observer without going up to the anemometer or windvane which are usually located in places not easily accessible. The present paper describes an equipment consisting of an electronic wind speed indicator and a wind vane using selsyn motors. In the electronic wind speed indicator, an r. f. voltage with a frequency of 20 Kcs. generated in the observer's room is fed through a pair of cables into a coil fixed in the box carrying the spindle of the 4-cup anemometer. Another coil is fixed just below the first coil and the voltage induced in this is fed into an amplifier through a pair of shielded cables. A brass circular vane with ten sectors fixed on the anemometer spindle and rotating in the space between the two coils makes the induced voltage fluctuate at a frequency which is proportional to the rate of rotation of the anemometer cups. The induced voltage is amplified and the varying portion of the voltage further amplified and converted into square wave pulses of constant amplitude and then fed into a frequency discrimination circuit which indicates the frequency of the voltage variation by means of a micro-ammeter calibrated in miles per hour. The paper also describes the advantages of this method over some of the other methods in use.

1. *Introduction.*

Wind is measured with two instruments, viz. an anemometer which gives the velocity and a vane which gives the direction. Sometimes, these instruments are combined in one unit. They are usually installed at a place where an unobstructed flow of wind is available from all directions, and such exposures can be obtained on the topmost part of a building or on a specially constructed wooden tower where the observer has to climb up to get the readings. With the recent developments in aviation when planes land or take off frequently from an air port these observations are required very frequently and it will mean both inconvenience and delay, if the observer has to reach the instruments every time. Designs were, therefore, developed with which the readings of the wind velocity and the direction are indicated in the observer's room itself.

2. *Some common types of Distant Reading Anemometers.*

The general principles adopted for the measurement of wind speed in the most common type of instruments are

(*i*) The cup anemometer in which the wind movement is measured by the rate of rotation of the cups which is proportional to the wind speed.

(*ii*) The pressure tube anemograph which employs the pitot tube system.

The pressure tube anemograph is an elaborate instrument, requiring special installation. It can be used to indicate the wind velocity and the direction over the roof of the building, if the observer has his office room vertically below, as the rod indicating direction runs vertically from the vane to the recorder. Designs have, however, been made by which the indications of the pens on the recorder are repeated wherever required by employing suitable Selsyn motors. This is too elaborate an arrangement and our requirements can be more easily achieved by using the cup anemometer for the purpose.

To modify the cup anemometer to a distant indicating type, different methods have been adopted. For example, by fixing a suitable electric contact in the anemometer gear box, which makes contact momentarily for every 1/10 mile run of the cup and by connecting an electric bulb or buzzer in the circuit, at the observing place, the wind speed is calculated from the time interval between the flashing of the bulb.

Instruments have also been developed in which a small permanent magnet generator directly connected to the cup spindle, indicates the wind speed on a voltmeter, calibrated in terms of wind speed. No external power is required for this instrument. It has, however, its defects and drawbacks. The generator exerts a drag on the free movement of the anemometer cups; the readings on the scale are affected to some extent by the length and size of the cables, used from the anemometer to the indicator.

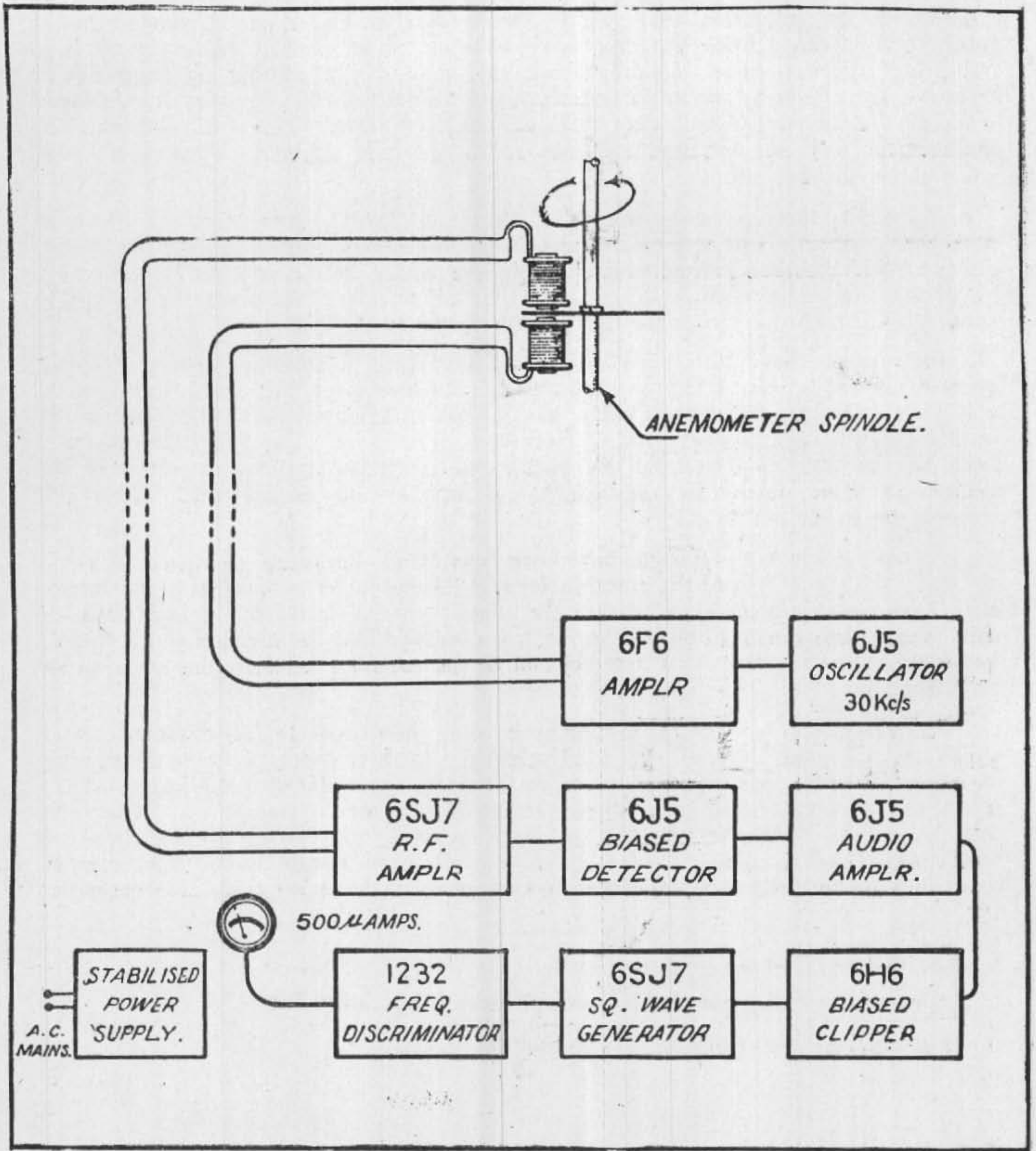
Recently a number of designs have been developed, adopting electronic devices. In these, the movement of the anemometer spindle affects the constants of an electronic system and this is made to indicate the wind speed. From the descriptions of this type of instrument published so far, it is observed that the rotation of the spindle varies either the constants of a tuned circuit or the coupling between the coils of an oscillator.[1,2]

The variation in the oscillator current is then measured by a frequency meter which is calibrated to read the wind velocity. In these cases, the cable connecting the anemometer to the indicating instrument becomes a part of the oscillatory circuit and as such it cannot be altered without affecting the circuit constants. To overcome this, either the oscillator unit has to be kept along with the anemometer itself or high quality low loss cables of standard lengths will have to be used. The present paper describes a method by which the disadvantages of the above types are overcome.

3. *The principle of the new electronic system.*

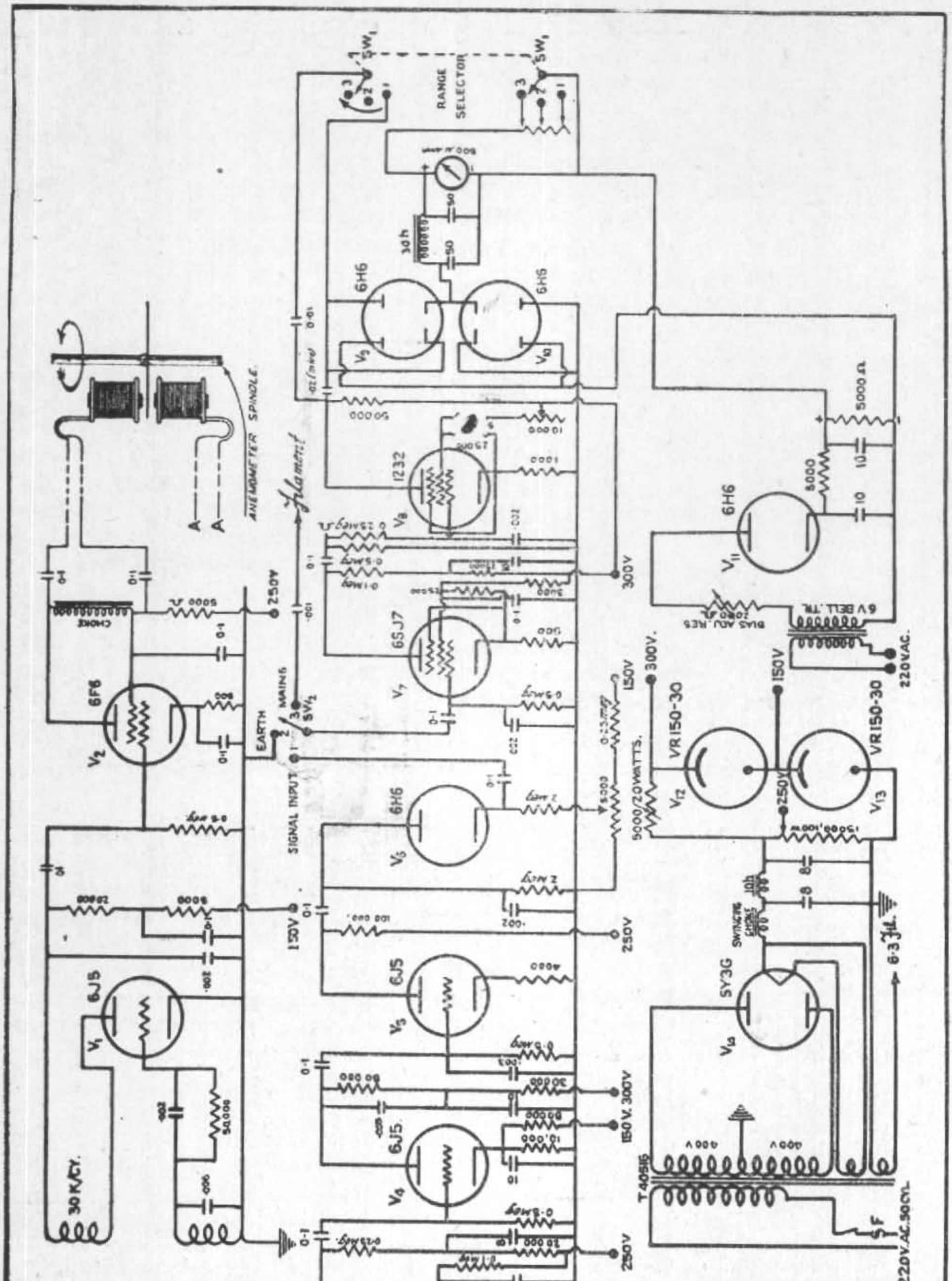
The schematic diagram of the electronic device is given in Fig. 1.

The detailed circuit diagram is given in Fig. 2.



BLOCK DIAGRAM OF THE ELECTRONIC ANEMOMETER

Fig. 1.



● ALL CONDENSERS ARE IN MICROFARADS & RESISTANCES IN OHMS. ●

CIRCUIT DIAGRAM OF DISTANT READING ELECTRONIC ANEMOMETER

Fig. 2.

A radio-frequency voltage of 30 kilocycles/second, generated in an oscillator and amplifier unit in the observer's room is fed to a coil fixed in a small housing in the base of the cup anemometer. Just below this coil is fixed another similar coil, in which a voltage is induced due to the mutual inductance between the two. The anemometer spindle carries a small brass disc, with a number of slots and this disc rotates between the coils. As the disc rotates, it varies the coupling between the coils and the amplitude of the induced voltage in the lower coil varies at a rate depending on the speed of rotation of the spindle or indirectly to the velocity of the wind. This induced voltage is fed into an amplifier in the observer's room and then fed to a biased detector which passes off only the varying portion of the voltage. The R. F. voltage is by-passed and the varying portion is amplified by a 6J5 stage and then converted into semi-square pulses by a biased diode, which also cuts off all extraneous pick-up voltages. These semi-square pulses should be converted into square topped pulses of constant amplitude, because when these are fed to the frequency discriminator circuit, each pulse must produce the same amount of current in the plate circuit of the discriminator valve. The next stage, therefore, converts the input into square-topped pulses of constant amplitude and these are fed to the frequency discriminator stage which is initially biased to cut-off. As each pulse is fed, the discriminator stage passes a constant current and a condenser in the plate circuit which is charged through the plate load from the constant H. T. supply, discharges almost completely through the discriminator valve. The charging and discharging current through the condenser is the same for each pulse, as the H. T. supply is stabilised and as all the pulses have the same amplitude and shape. As the frequency of the pulses increases, the average current through the condenser also increases linearly up to a certain limit, depending on the value of the condenser and the average current is measured by a micro-ammeter connected through a bridge circuit of four diodes, across the condenser.

Thus faster the anemometer spindle rotates, greater is the modulation frequency and larger is the current through the micro-ammeter. The meter is calibrated to give the wind velocity directly in knots.

Wind velocities above 50 knots are not frequent and the maximum that one may encounter will be of the order of 70 knots. With the standard type of cup anemometers used in the India Meteorological Department, the velocity of 70 knots corresponds approximately to a modulation frequency of 100 cycles/second. To increase the accuracy of the readings, three ranges have been provided and any one of them may be used by a selector switch. The ranges are 0 – 25, 0 – 50 and 0 – 75 knots and they are marked directly on the micro-ammeter dial. Even a wind as low as 2 miles per hour will make a noticeable change in the current through the meter.

The two coils and the rotating disc on the spindle are housed in a brass box, which has a cover on one side for inspection and easy access.

Two two-core cables connect the coils in the anemometer to the indicating unit. The losses in the cable are very small as the frequency used is fairly low. A stabilised power supply is used so that the variations in the mains voltage do not affect the readings.

To check the calibration of the frequency meter a low voltage of the mains 50 cycles supply is introduced into the input of the frequency meter through a switch and if the calibration is correct, the readings on the dial for the 75 and 50 knots range should be 31.5 and 31.2 respectively. The screen voltage of the frequency discriminator stage is varied slightly by means of a potentiometer so that the reading of the frequency meter can be altered. If the frequency reading of the mains supply is not correct, then it can be adjusted by means of the potentiometer; the accuracy of the calibration can be checked thus whenever required. The input of the frequency meter is earthed through a switch, so that the zero position of the pointer can also be checked. Even though there is no input to the four diodes connected in a bridge circuit, there will always be a small amount of emissive current flowing through the micro-ammeter, and this is suppressed by applying a small negative bias to the plates of the diodes. This bias is obtained independently from the rectification of the mains voltage by a 6H6 valve and it can be varied slightly by means of a variable resistance. By adjusting this resistance, we can bring the emission current of the diodes to zero and this has to be done after grounding the input of the frequency meter by means of the selector switch.

The scale of the meter is linear and the wind velocities can be recorded by using a recording current meter.

In this instrument, there is no electrical or mechanical drag on the anemometer spindle except for the light friction at the bearings. The cups are therefore, free to start at low wind speeds and to respond to gusts.

We can have more than one indicator for wind velocity, distributed over a place.

4. *Constructional details.*

The standard type of four cup anemometer manufactured in the Meteorological Office at Poona and used at all observatories in India, is mounted on a 1" galvanised iron pipe, 15" in length (Fig. 4). This pipe is screwed on to the brass housing with a flanged base for mounting. The housing has a front cover which is fixed to it by means of screws. The standard anemometer spindle with its worm, gear and veeder counter is replacedby a straight piece of $\frac{1}{4}$" brass rod, 15" in length and its lower end rests on a ball in a housing. The worm which engages with the gear and counter to measure the run of the wind is replaced by a circular brass disc with ten vanes. Two coils of low impedance are wound on tufnol formers and fixed in the housing at a distance of $\frac{1}{8}$" between their centres and the brass disc rotates between these coils.

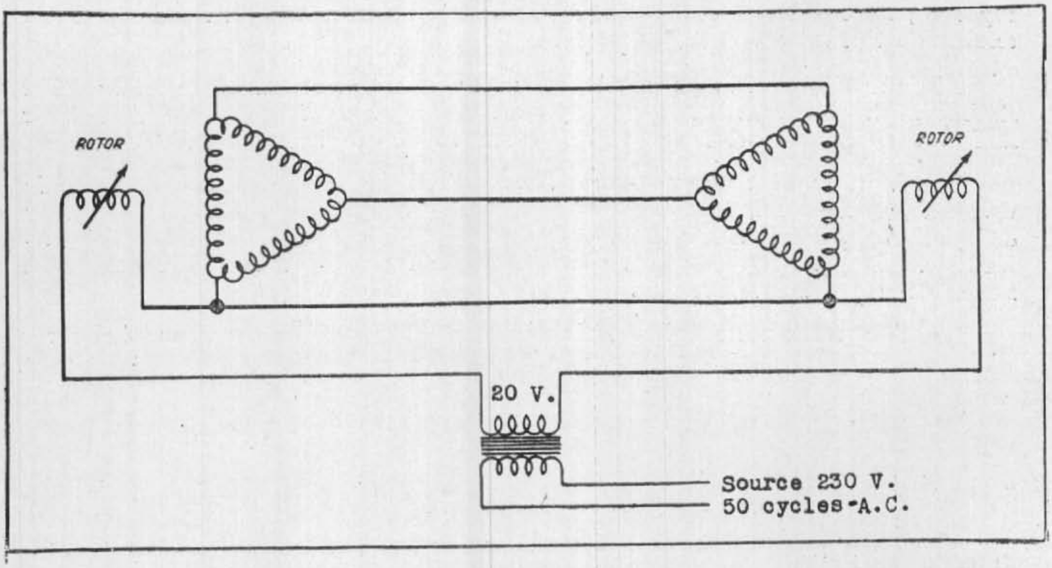
If the disc makes one complete revolution in one second, then the number of vanes passing through the coils in one second is ten and the modulation frequency in the secondary coil will be 10 cycles/second. The standard I.M.D. anemometer makes 500 revolutions per minute or 5/36 of a revolution per second for a wind speed of 1 knot. A wind speed of 3 knots will make the disc rotate through 5/12 of a complete revolution in one second and this produces a modulation frequency of about 4 cycles/second which can be easily read in the frequency meter. The sensitivity can be further increased by increasing the size and the number of vanes in the brass disc.

5. *The distant reading windvane.*

To indicate the direction of the wind at a distant point, the motion of the vane should be communicated to a pointer, at the observer's room and this can be easily done with the help of a synchro-mechanism.

A synchro-mechanism comprises of two units—a transmitter and a receiver. Both of them are of identical construction and each has a stator and a rotor, built of steel laminations and wound with coils of wire. The rotor has two poles and one winding. Connection to the winding is made through brushes resting on sliprings. The rotor shaft is either coupled to the spindle of the rotating vane or to a pointer.

The stator is cylindrical and slotted and carries three windings, each distributed in several slots.



4 WIRE SYSTEM, ROTORS IN SERIES.

Fig. 3

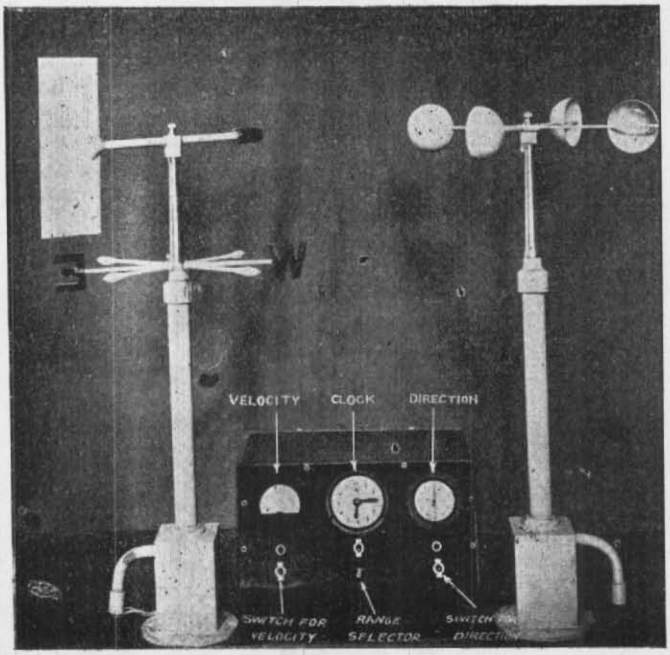


Fig. 4

Corresponding stator terminals of the transmitter and receiver are connected together; corresponding terminals of the rotors are connected together and the rotor terminals are connected to the single phase A.C. supply (Fig. 3).

Altogether four wires are run between the transmitter and the receiver. The shaft from the windvane is coupled to the rotor shaft of the transmitter and the rotor shaft of the receiver carries a pointer, which moves over a circular graduated dial.

The I.M.D. small types windvane and No. 670 Selsyn motors of Central Scientific Company, Chicago are used for this purpose. The Selsyn motors are originally designed for operation on 110 volts, 400 cycles per second, but they work satisfactorily with 20 volts 50 cycles A.C. and this is supplied from the 230 volts mains with a suitable step-down transformer.

The Selsyn transmitter is housed in a brass box, identical to the one used for the distant reading anemometer (Fig. 4). The windvane is mounted on a 1" pipe, 15" long, screwed on the brass housing. The vane carries a long spindle, which is coupled to the Selsyn transmitter.

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2. Ives, R. L., Some Instrumental defeciencies of cup anemometers, *Jour. of Met.*, III 4, 122–23, (1946).