An irrigation control system having control modes which can be selected in accordance with calendar periods in respect of each output irrigation valve controller in which a first Mode controls on the basis of replenishment on a period which preselected by the operator, Mode 2 operates to have a variable frequency depending upon changes in climatic circumstances either predicted or taken from real inputs, and there is finally a third Mode which is a maintenance mode.
DESIGNATIONS OF “DE”

Until further notice, any designation of “DE” in any international application whose international filing date is prior to October 3, 1990, shall have effect in the territory of the Federal Republic of Germany with the exception of the territory of the former German Democratic Republic.

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IRRIGATION MANAGEMENT CONTROL

This invention relates to irrigation and watering systems and more particularly to a watering or irrigation system which can provide for a more effective application of water to areas to be irrigated.

The use of "controllers" to regulate and control the irrigation of turf and other decorative swards and plants is well known. Hitherto however such control has been on the basis that the operator assigns "run times" to various outputs of the controller which then executes these programs; or the controller may be connected to some kind of potential evapotranspiration or soil moisture tension sensor which can initiate and/or limit the activity of the controller.

Such techniques effect different results on the plants and depending upon the total climatic situation will variously cause a high or low stress on the plants which in terms of preferred management of plants is less advantageous and can be somewhat uneconomic in terms of the amount of water used.

My discovery in relation to this invention is to realise that there are at least two quite different modes of operation which can be used and that indeed these can be combined in a single controller so that there is no longer the extent of comprise that has hitherto had to be made.

The concept is therefore to incorporate in relation to any controller controlling some irrigation outlet valve, that there can be at least two different modes by which the outlet is controlled and that the controller can be arranged so that at some times, one of the modes is in control, and that at other times the other mode is in control.

In the one case, it is relatively simple to provide that the frequency at which the watering cycle starts shall be fixed.

In the other mode, it shall be provided that the frequency at which watering starts is not fixed in accordance with a preselected time within the controller such time being determined by the operator but rather such a time is in accordance with calculations based upon either a calendar based assessment
of climatic conditions or by input of climatic assessments arising from external sources.

In preference there is a third mode which is when watering is no longer called for at all but where an opening and closing of valves and a flushing of the system is of great value.

In further explanation of the problem, the plants are known to lose a substantial proportion of moisture through their leaves on days in which humidity, temperature and wind velocity are above certain criteria.

However, moisture loss from roots even on the worst of days can be significantly less but in such cases, the plant can be put in a position of extreme stress which can at least to some extent be relieved by very frequent watering.

On days in which the temperature, humidity and wind directions are not so severe, stress of the plant is not such a problem but it then becomes a problem to ensure that the roots of the plant will on a regular basis be strengthened and be extensive so that in times of harder climatic conditions, the plant has such an extra reserve that is can call upon.

It is well known of course that if frequent but relatively light watering events occur then over time, the plants will develop root growth appropriate for such watering regime which will not be deep and to this extent, the plants become dependent upon such frequency fixed waterings so that the plants further do not have roots extending deeply into the soil obtaining additional nutrients.

Further, the plants become mechanically fragile with shallow root growth in the sense that they can be easily detached from location within the surface of the earth and all in all, it is a real problem if there is this regular fixed frequency and therefore frequent watering technique.

In accord with this invention then the invention can be said to reside in an irrigation control system comprising a controller having a memory, a central processing means, a clock and output control means, the memory including a program operative through the central processing means and the clock
whereby to effect an operative control of the output control means which are
adapted to control one or more irrigation water control valves such that is
respect of at least two different periods of time there is effected in respect of a
first period, a control of a selected one of the irrigation water control valves in
accord with a first mode of control, and in respect of a second period, a control
of the said selected irrigation water control valve in accord with a second mode
of control, the first mode of control being such that the times at which the
selected valve is open is in accordance with times preset by an operator within
the program, and the second mode of control is such that the times on which
there is an opening of a selected valve is not in accordance with any pre-set
time input by an operator into the program.

In preference, such second mode of control is such that the time of opening of
the selected valve is only subsequent to a selected extent of water being lost in
the ground to which the valve is controlling water supply.

In preference the second mode of control is such that the time of opening of a
selected valve is in accordance with an Optimum Irrigation Event.

Such an optimum irrigation event can be defined in various ways and in
practice has for its purpose to effect an irrigation on the basis that this will
encourage outside of exceptional periods, adequate root growth for additional
strengthening and access to nutrients for the plants being nurtured.

In preference such an optimal irrigation event can be such that the second
mode of control causes the time of opening the selected valve to be only
subsequent to a selected extent of water being lost to that ground to which the
valve is controlling water supply and then open for a period sufficient to restore
substantially that total selected extent of water.

It is generally considered that once irrigation is commenced, then irrigation
should continue for a period which will be such that substantially that water
which is necessary to restore a selected total of water to the ground volume
necessary for optimum water concentration shall be effected.
This does not mean that there shall not be intermittent opening and closing of the control valve which can be effected for the purpose of controlling the rate at which the water is applied in a relatively short period thereby reducing run-off problems.

The capacity for any soil to take up water is limited so that if the water due to the size of the irrigation capacity is larger than the immediate soakage capacity of the soil, then it is often expedient so to supply the necessary total of water in bursts that can be broken by short periods.

Such stopping of the control valve and opening however is over relatively short time and is to be distinguished from a commencement of watering period which will inevitably be longer than some two or three hours and almost always will be separated by a period of at least one day.

The technique by which the second mode can effect a watering calculation can variously be either by way of a calendar within the memory of the controller coupled to information regarding the climatic conditions that are conventionally expected within the locality during the selected calendar periods or it can be by way of input from external information or devices.

Typically, an external device can comprise a water concentration detector located within the ground either in the vicinity of the area to be located or in a typical vicinity so that the similar conditions can be expected to apply.

It is further to be emphasised that the first mode of control will also use external input so as to provide if required an assessment of the quantity of water that will be necessary to restore the total level of water in the soil to the optimum level and to this end, external devices such as soil moisture meters can be used and may be incorporated within the total control apparatus.

The mode of control however is different in that the commencement of a irrigation event will be in accord with a precisely input start-up time in Mode 1 whereas in Mode 2 the start-up time will be such as to ensure that an expected increase in plant stress will be caused with the expected result that the plants will be caused to seek greater root depth and strength to the benefit of both the
plant and the economics of the irrigation process.

The invention may be better understood when referred to an embodiment which will now be described with the assistance of drawings in which:

FIG. 1 is a graphical representation of the difficult moisture content profile during a period of time subjected to in the one case Mode 2 type control and under similar environmental conditions,

FIG. 2 shown as being subjected to Mode 1 type irrigation control,

FIG. 3 simply illustrations in a relatively simple manner the respective depths to which a Mode 1 type controlling system might be applicable, whereas a Mode 2 system will be able to effect root growth to a much deeper extent and a schematic layout of the controller and input,

FIG. 4 is a block layout of functional elements effective in the controller, and

FIG. 5 is a matrix table showing a possibly typical selection program for respective calendar periods and in respect of a variety of different stations.

Referring firstly to Fig. 1, this illustrates a typical watering period of some eleven days in which on every second day that is day 2, day 4, etc., a locality is watered raising the adequate moisture control depths some two units on the second day, some one unit on the fourth day, some three and a half units on the sixth day, some one unit on the eighth day and some two units on the tenth day.

As will be seen, the watering period is caused to commence on a regular pre-set basis that is in this case two days and the period of watering after the commencement of the watering cycle, is such that the adequate moisture control depth will in each case reach an approximately constant level immediately subsequent to the watering event.

Such a regular cyclic water event can be varied perhaps on a monthly basis or of course any calendar basis but because it does not take into account any
need for plants on a regular basis to seek more deeply watering and perhaps more importantly does take into account in most difficult climatic times, the need for regular watering, this provides a quite specific technique for watering.

In Fig. 2, this illustrates Mode 2 style control in which the actual time at which the irrigation event will occur is not input directly by the operator but rather it is arranged that within a selected period, the opening of the irrigation control valve will be governed by a selected degree of reduction in water content within the soil and it is this that will control the commencement of the irrigation event.

Typically then in Fig. 2, there is shown that there is a gradual decrease broadly proportional to the period up to four days at which there is a return to a given adequate moisture control depth of water, then a further three days occurs before the next irrigation event returning this once again to the adequate level and of course over the next four days the value is again dropping.

Self evidently these are simply typical values showing however the quite different mode by which the two controlling techniques operate.

It will by now be quite self evident that the technique for controlling the water control valves will be an appropriate technique but this is now found to be appropriately that devices which can provide interpretation ability with respect to input data, and such that the data can except an input from an operator but will then calculate from such input data to provide in results which are effective for controlling water control valves.

This inherently in present times involves a microprocessor type controlling type system and this includes a centrally processing unit, ROM and RAM type memory, a clock effecting on a regular basis program instructions and also effecting a counting of time for controlling of irrigation events and the period over which the irrigation event will occur and finally will have input from such external devices as are appropriate.

Accordingly in Fig. 3 there is shown a plurality of plants 10 which have a root structure such as at 11 below the ground extending to various depths as shown by arrows 12 as indicating relatively shallow depth type levels and 13 showing
relatively deep levels.

There is a control system operating a plurality of water control valves such as at 14, 15, 16 and 17 and so on and each of these is controlled by an electric control system shown as operative control unit 18, 19, 20 and 21.

These is turn are controlled through a central processing unit 22 which is in turn controlled from a read only memory program 24 and an erasable program 25 which however includes an operative control program which has been input from an operator selection process.

There is a clock adapted to operate the central processing unit.

The operative program includes a calendar, and a real time clock which interrogates the calendar on a regular basis to effect a calendar responsive operation of various functions by the central processing unit.

The key to all of this as far as the embodiment and newness is concerned is that this operates in accord with any preselected calendar period defined by days and in respect of each chosen station, in accord with either a Mode 1, Mode 2 or Mode 3 operation.

The mode operation is selected entirely by the operator prior to setting of the controller into an operating mode and the typical way in which this done is shown in Fig. 5 which is a matrix showing a typical selection of periods of a calendar year and in accordance with the embodiment, each unit shown is a fortnight calendar period but the whole of 26 such periods for a year is not shown simply because of space considerations in a drawing of this type.

However, 26 periods of two weeks are incorporated and this is then selectable in relation to each station in respect of each such two week period.

The Mode 1 is effective within the program to control the operating mode of the respective station control valve so that as a further selection, the program requires the operator then to fix the frequency at which, on a day by day basis, the control valve will be switched on.
The period for which the valve will be opened will depend then upon other matters but is selected such that the quantity of water will then refill the soil reservoir.

5

The calculation for the run time is as follows:

\[
\text{run time} = \frac{\text{volume to be applied over flow rate where volume to be applied is daily evaporation (class A pan), } X \text{ by pan factor } X \text{ by irrigation factor } X \text{ by size of area to be irrigated by station in question } X \text{ by the number of days which has been pre-set}}
\]

10

Typically then, there might be a daily evaporation of 8 mm, an irrigation frequency of 3 days and a 50 sq m irrigation area with a flow rate of 1500 litres per hour then from a calculation \(8 \times 0.8 \times 0.7 \times 50 \times 3 = 672 \) litres so that one time is \(672 \times 60 / 1500 = 27 \) minutes. In Mode 2 however it is necessary to calculate the optimum irrigation event and apply this as often as necessary within the periodic limits such as the period during night and day that might be a constraining factor.

15

Accordingly the general equation to find the irrigation event which will fill a selected root zone to fill capacity for a minimal capacity is:

\[
\text{AW} \times \text{RZD} \times \text{Area} = \text{Volume of full depth irrigation}
\]

20

\[
\text{AW} \times \text{RZD} \times \text{Area} / \text{Flow rate} = \text{Time of full depth irrigation}
\]

25

where:

\[
\text{AW} = \text{Available water}
\]

\[
\text{RZD} = \text{Required Root Zone Depth}.
\]

30 However, one can rarely permit plants to extract all the available water prior to irrigating again, because it can be too difficult and stressful to extract the last of the available water. For this reason the system allows the operator to specify a Depletion Factor (DF) for each station in each period. This means that if a DF of 60% is specified, then only 60% of the AW will be used before a further irrigation occurs and the size of that irrigation will be 60% of the irrigation required to fill the required root zone to Field Capacity. This latter irrigation is
the Optimum Irrigation Event - OIE.

Therefore, in principle the Optimum Irrigation Event (OIE) is calculated:

\[
5 \quad \text{OIE} = AW \times RZD \times \text{Area} \times DF \text{ for volume; or}
\]

\[
10 \quad \text{OIE} = AW \times RZD \times \text{Area} \times DF / \text{Flow rate for time.}
\]

In terms of working out how often to repeat the OIE, assume that we start with the root zone filled to Field Capacity and subtract each day's contribution to the evaporation until we get down to the threshold level which will equal

\[
15 \quad (AW \times RZD \times (1 - DF)).
\]

For example, assume we are dealing with a sand of 0.75 mm/cm Available Water, and a root zone depth of 300 mm, we are watering an area of 50 sq m with a flow of 1500 l/hour, and we wish a DF of 60%:

\[
15 \quad \text{OIE} = 300/10 \times 0.75 \times 50 \times .6 = 6751 \text{ (Volume), or}
\]

\[
15 \quad \text{OIE} = 300/10 \times 0.75 \times 50 \times .6 / 1500 = 27 \text{ mins (time).}
\]

\[
20 \quad \text{For irrigation frequency:}
\]

\[
20 \quad TAW = 300/10 \times 0.75 = 22.5 \text{ mm}
\]

\[
20 \quad MAW = 22.5 \times (1 - 0.6) = 9 \text{ mm}
\]

\[
20 \quad RAW = TAW - (MDE1.F1...Fn)
\]

\[
25 \quad RAW1 = 22.5 - (6 \times 0.8 \times 0.7) = 19.14
\]

\[
25 \quad RAW2 = 19.14 - (6 \times 0.8 \times 0.7) = 15.78
\]

\[
25 \quad RAW3 = 15.78 - (6 \times 0.8 \times 0.7) = 12.42
\]

\[
25 \quad RAW4 = 12.42 - (6 \times 0.8 \times 0.7) = 9.06
\]

Where TAW = Total available water

\[
30 \quad MAW = \text{Minimum allowable Available Water}
\]

\[
30 \quad RAW = \text{Residual available water}
\]

\[
30 \quad RAW1 = \text{Residual available water at end of day 1 etc.}
\]

It can be seen that at the end of day 4 in the above example that RAW4 = MAW, so irrigation would occur at the next opportunity. Therefore the schedule in this example would be to water for 27 minutes every 4 days.
The calculation for the optimal irrigation event can either use a climate profile which is incorporated within the memory which is appropriate for the area of irrigation or it can incorporate real time information coming in from external detectors.

Such external detectors can include weather information from external detection devices or that can also include soil moisture devices such as is shown in Fig. 3 at 27 and 28 where the soil moisture at at least two levels is detected, and there is shown an external environment or it can include humidity measurements means and wind velocity.

Finally, Mode 3 is a maintenance mode and here whereas the purpose is simply to have a regular flush through of water in the system, it therefore is simply a matter of regularity of a small operating period for maintenance purposes only.

This then illustrates the preferred example from which it will be seen that there are applicable three modes, Mode 1 adapted to assist the plant through a stressful period of the year in terms of external temperature or the like, Mode 2 applies a developmental irrigation which can thus both save water and maximise root volume, and Mode 3 assists in maintaining the system in good condition during a period in which irrigation might normally not be necessary.

Taken together these factors allow a suitable control as so programed and equipped to provide a level of management unavailable in prior art controlism by other means and to maximise an amenity value while minimising water use.

Accordingly it will be seen that there is provided according to the invention an improvement irrigation management control system in which the controller is able to increase the efficiency of the irrigation by applying water at the times and rates to overcome the periods which are most stressful to the plant and to also water during other times which are most desired by the plant for its efficient development or in other words the watering mode provides optimal watering characteristics for root development during periods during which the above ground climatic conditions are not going to cause undue stress to the plant.
Inputs into the controller when in a Mode 2 development mode can use data on soil type, soil slope and required root depth, and this of course can then be applied at quite irregularly intervals when it is deemed to be necessary either on the basis of real world data such as that provided by the operator with access to such data, or an online weather station or weather reporting service, or by an appropriate soil or plant based sensor system or by reference to a library of expected potential evapotranspirations based upon historical observations.

Superimposed over any of the modes can be constraints on the controller for instance that no matter in what mode, irrigation will not take place during a selected period of time where for instance an operator may be wishing to do maintenance work or there may be an external event which makes it inappropriate for such watering.

Further, there is the possibility of effecting watering on a periodic basis during a short period simply to reduce possible run off as previously explained.
1. An irrigation control system comprising:
a controller having a memory,
a central processing means,
a clock and output control means,
the memory including a program operative through the central processing means and the clock
whereby to effect an operative control of the output control means which are adapted to control one or more irrigation water control valves,
such that in respect of at least two different periods of time there is effected
in respect of a first period, a control of at least a selected one of the irrigation water control valves in accord with a first mode of control,
and in respect of a second period a control of the said selected irrigation water control valve in accord with a second mode of control,
the first mode of control being such that the time at which the selected valve is
opened is in accordance with times preset by an operator into the program,
and the second mode of control is such that the time at which there is an
opening of the selected valve is otherwise than in accordance with any preset
time input by an operator into the program.

2. An irrigation control system comprising:
a controller having a memory,
a central processing means,
a clock and output control means,
the memory including a program operative through the central processing means and the clock
whereby to effect an operative control of the output control means which are adapted to control one or more irrigation water control valves such that in respect of at least two different periods of time there is effected in respect of a first period,
a control of at least a selected one of the irrigation water control valves in accord with a first mode of control,
and in respect of a second period a control of the said selected irrigation water control valve in accord with a second mode of control,
the first mode of control being such that the time at which the selected valve is
opened is in accordance with times preset by an operator into the program,
and the second mode of control is such that the times on which there is an
opening of the selected valve is calculated within the program and is calculated as being only subsequent to a selected extent of water being lost to the ground to which the valve is controlling water supply.

3. An irrigation control system comprising:
   a controller having a memory,
   a central processing means,
   a clock and output control means,
   the memory including a program operative through the central processing means and the clock whereby to effect an operative control of the output control means which are adapted to control one or more irrigation water control valves such that in respect of at least two different periods of time there is effected in respect of a first period a control of a selected one of the irrigation water control valves in accord with a first mode of control,
   and in respect of a second period a control of a selected one of the irrigation water control valves in accord with a second mode of control,
   the first mode of control being such that the times on which there is an opening of the selected valve is in accordance with preselected times within the program,
   and the second mode of control is such that the time at opening of the selected valve is only subsequent to a selected extent of water being lost to the ground to which the valve is controlling water supply.

4. An irrigation control system comprising:
   a controller having a memory,
   a central processing means,
   a clock and output control means,
   the memory including a program operative through the central processing means and the clock whereby to effect an operative control of the output control means which are adapted to control one or more irrigation water control valves such that in respect of at least two different periods of time there is effected, in respect of a first period a control of a selected one of the irrigation water control valves in accord with a first mode of control,
   and in respect of a second period a control of a selected one of the irrigation water control valves in accord with a second mode of control,
water control valves in accord with a second mode of control, the first mode of control being such that the times at which there is an opening of the selected valve is in accordance with preselected times within the program, and the second mode of control is such that the time at opening of the selected valve is only subsequent to a selected extent of water being lost to the ground to which the valve is controlling water supply and then continuously or intermittently over the period for a period sufficient to restore substantially that total selected extent of water.

5. An irrigation control system comprising:
   a controller having a memory,
   a central processing means,
   a clock and output control means,
   the memory including a program operative through the central processing means, and the clock whereby to effect an operative control of the output control means which are adapted to control one or more irrigation water control valves such that in respect of at least three different periods of time there is effected in respect of a first period a control of a selected one of the irrigation water control valves in accord with a first mode of control, in respect of a second period a control of a selected one of the irrigation water control valves in accord with a second mode of control, and in respect of a third period a control in accord with a third mode of control, the first mode of control being such that the times on which there is an opening of the selected valve being in accordance with preselected times within the program, the second mode of control being such that the times on which there is an opening of the selected valve is in accordance with replacing a selected loss of water in the ground being serviced by the valve, and the third mode is such that a minimal quantity of water is caused to flow on a regularly repeated time basis so as to enable a maintenance of the irrigation equipment.

6. An irrigation control system as in any one of the preceding claims further characterised in that
there is a calendar within the memory, and means to effect a calculation of water losses in accord with predicted evaporation rates at selected periods during a year as established by the calendar, in the location of the controller such that the second mode of control is such that the time at opening of the selected valve is only subsequent to a thus calculated extent of losses of water supply which is lost to the ground to which the valve is controlling water supply.

7. An irrigation control system comprising:

10 a controller having a memory, a central processing means, a clock and output control means, the memory including a program operative through the central processing means and the clock whereby to effect an operative control of the output control means which are adapted to control one or more irrigation water control valves such that in respect of at least two different periods of time there is effected, in respect of a first period a control of a selected one of the irrigation water control valves in accord with a first mode of control, and in respect of a second period a control of a selected one of the irrigation water control valves in accord with a second mode of control, the first mode of control being such that the times on which there is an opening of the selected valve is in accordance with preselected times within the program, and the second mode of control is such that the time at opening of the selected valve is only subsequent to a selected extent of water being lost to the ground to which the valve is controlling water supply and then opened and kept open either continuously or intermittently over a relatively short period but for a period sufficient to restore substantially the total of the selected extent of water the means for effecting an assessment of the extent of water being lost being selected from one or more of the following, namely soil moisture detection means, wind detection means, humidity detection means, or temperature detection means.
8. An irrigation control system comprising:
   a controller having a memory,
   a central processing means,
   a clock and output control means,
   the memory including a program operative through the central processing
   means and the clock
   whereby to effect an operative control of the output control means which are
   adapted to control one or more irrigation water control valves,
   such that in respect of at least two different periods of time there is effected
   in respect of a first period a control of a selected one of the irrigation water
   control valves in accord with a first mode of control,
   and in respect of a second period a control of a selected one of the irrigation
   water control valves in accord with a second mode of control,
   the first mode of control being such that the times on which there is an opening
   of the selected valve is in accordance with preselected times within the
   program,
   and the second mode of control is such that the time at opening of the selected
   valve is only subsequent to a selected extent of water being lost to the ground to
   which the valve is controlling water supply and then opened for a period either
   continuously or intermittently for a sufficient time to restore substantially the total
   of the selected extent of water,
   the means for effecting an assessment of the extent of water being lost
   comprising at least one external detector of soil moisture.

9. An irrigation control system as in any one of the preceding claims further
   characterised in that a run time after any opening of the water control valve can
   either be continuous or intermittent to limit run off.

10. An irrigation control system as in any one of the preceding claims further
    characterised in that the controller is adapted such that each time input by an
    operator for operation of the controller in the first mode will be each be caused
    to be separate by at least twenty four hours.
11. An irrigation control system as in any one of the preceding claims further characterised in that the controller is adapted such that times input by an operator for operation of the controller in the third mode will each be different by at least twenty four hours.

12. An irrigation controller as in any one of the preceding claims further characterised in that the periods of time for which a selected one only of the modes can operate comprises one or a multiple of the period of two weeks

13. An irrigation controller substantially as described in the specification with reference to and as illustrated by the accompanying drawings.

14. An irrigation controller system substantially as described in the specification with reference to and as illustrated by the accompanying drawings.
Fig 2
I. CLASSIFICATION OF SUBJECT MATTER

According to International Patent Classification (IPC) or to both National Classification and IPC

Int. Cl.\(^5\) A01G 25/16, G06F 15/46

II. FIELDS SEARCHED

Minimum Documentation Searched 7

<table>
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III. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
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<tr>
<td>P,X</td>
<td>AU/A, 44183/89 (SOLATROL INC.) 1 May 1990 (01.05.90) Whole document, see in particular page 13, line 9 to page 17, line 1; and page 19, line 16 to page 21 line 2</td>
<td>Claim No 13</td>
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<tr>
<td>X</td>
<td>AU/A, 27838/89 (JAMES HARRIE IRRIGATION INC.) 23 May 1989 (23.05.89) Whole document, see in particular pages 4-5</td>
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<tr>
<td>P,X</td>
<td>US/A, 4922433 (ARNOLD MARK) 1 May 1990 (01.05.90) Whole document</td>
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<td>X</td>
<td>AU/A, 68726/82 (DWIGHT J. BUSALACCHI) 14 April 1983 (14.04.83) Whole document, see in particular pages 4,7,9,14 and 15, and claims 12 and 14</td>
<td>(1-12)</td>
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<td>AU/A, 68428/27 (AUDITEL SYSTEMS PTY LTD) 16 July 1987 (16.07.87) Whole document, see in particular page 6 line 25 - page 7 line 21</td>
<td>(1-12) (contd)</td>
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* Special categories of cited documents: 10

- **"A"** document defining the general state of the art which is not considered to be of particular relevance
- **"E"** earlier document but published on or after the international filing date
- **"L"** document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- **"O"** document referring to an oral disclosure, use, exhibition or other means
- **"P"** document published prior to the international filing date but later than the priority date claimed
- **"T"** later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- **"X"** document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step
- **"Y"** document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
- **"&"** document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search 15 November 1990 (15.11.90)

Date of Mailing of this International Search Report 26 November 1990

International Searching Authority Australian Patent Office

Signature of Authorized Officer R. KIRBY
FURTHER INFORMATION CONTINUED FROM THE SECOND SHEET

| X | US A, 4176395 (RENE H EVELYN VERRE et al) 27 November 1979 (27.11.79) Whole document, see in particular pages 1-4 |
| X | FR A1, 2515839 (STE SELI SA) 6 May 1983 (06.05.83) Whole document, see in particular line 29, page 5 - line 1, page 6, claims 6 and fig 1 |
| Y | AU A, 77774/87 (WEINTRAUB M.H. et al) 2 March 1989 (02.03.89) Whole document, see in particular pages 3, 4 and the claims |
| Y | US A, 4165532 (THOMAS L. KENDALL) 21 August 1979 (21.08.79) Whole document, see in particular fig 1 |

V. [ ] OBSERVATIONS WHERE CERTAIN CLAIMS WERE FOUND UNSEARCHABLE 1

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. [ ] Claim numbers ..., because they relate to subject matter not required to be searched by this Authority, namely:

2. [X] Claim numbers 13, 14, because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

The reference to: "as described in the specification" and "as illustrated by the accompanying drawings" are not precise enough to allow for a meaningful search.

3. [ ] Claim numbers ..., because they are dependent claims and are not drafted in accordance with the second and third sentences of PCT Rule 6.4 (a):

VI. [ ] OBSERVATIONS WHERE UNITY OF INVENTION IS LACKING 2

This International Searching Authority found multiple inventions in this international application as follows:

1. [ ] As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims of the international application.

2. [ ] As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims of the international application for which fees were paid, specifically claims:

3. [ ] No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claim numbers:

4. [ ] As all searchable claims could be searched without effort justifying an additional fee, the International Searching Authority did not invite payment of any additional fee.

Remark on Protest
[ ] The additional search fees were accompanied by applicant's protest.
[ ] No protest accompanied the payment of additional search fees.

Form PCT/ISA/210 (supplemental sheet (2)) (January 1985)
This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

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