

FOCUS DETERMINING SYSTEM FOR A CAMERA

5 The present invention relates to a focus determining system for use in a camera for determining the range of a subject in dependence upon light reflected from the subject.

10 So called active focus determining systems are known, which comprise a light emitting element and a light receiving element disposed at a predetermined distance from one another and in which light from the light emitting element irradiates a subject and is reflected back onto the light receiving element as a
15 spotlight whereby the range of the subject can be calculated on the principle of triangulation.

 Such active focus determining systems may be classified into two types according to the functioning of the light emitting element. In the first type of
20 system, the light emitting element operates continuously at a constant modulation frequency of, for example, several tens of KHz. The second type of system constitutes a one shot system, in which the light emitting element produces a single burst of light
25 in every focus determining or range finding operation.

 While the former type of system is capable of generating reliable data and of minimising the influence of extraneous light by selectively extracting from the reflected light only a signal component tuned to the
30 modulation frequency of the light emitting element by means of a band pass filter, such a system nevertheless has the disadvantage that a condenser and a reactance coil are required for providing the band pass filter. Therefore, the number of parts is increased, which makes the circuitry bulky and difficult to incorporate

in a camera.

On the other hand, in the latter type of system,
5 the light emitting element can be actuated instantaneously to radiate a powerful burst of light and so the limits, which can be considered for the range of the subject, can be extended. Furthermore, a band pass filter is not especially necessary, which allows the
10 circuit configuration to be simplified and miniaturised. However, light from flickering light sources such as, for example, a fluorescent lamp, a neon sign, and a stroboscope and the light from the light emitting element cannot readily be distinguished. Consequently,
15 the data obtained may contain significant errors.

It is an object of the invention to overcome the problems mentioned above, and to provide a focus determining system for a camera which is capable of providing reliable range information by means of bursts of light
20 emission.

According to the present invention, there is provided a focus determining system for a camera, comprising a light emitting element and a light receiving element, means for controlling the light
25 emitting element to emit in a single range finding operation a pre-determined number of bursts of light for irradiating a subject, the light receiving element being arranged to generate a respective range finding signal in response to light reflected from the subject during
30 each burst of emitted light, means for integrating each range finding signal, and means for deriving a mean value for the range of the subject in response to an output of the integrating means.

The invention will be described further, by way of

example, with reference to the accompanying drawings, in which:-

5 Figure 1 is a block diagram showing the basic elements of a focus determining system according to the invention;

Figure 2 is a circuit diagram showing the system in greater detail;

10 Figure 3 is a diagram showing the signals generated at various points of the circuit illustrated in Figure 2;

Figure 4 is a flow chart representing the operation of the system;

15 Figure 5 is a diagram showing the signals generated at various points of the circuit illustrated in Figure 2 when modified to operate in an alternative manner;

Figure 6 is a flow chart representing such modified operation;

20 Figure 7 is a circuit diagram showing a first variation of the focus determining system of Figure 2;

Figure 8 is a flow chart representing the operation of the variation illustrated in Figure 7;

25 Figure 9 is a circuit diagram showing a second variation of the focus determining system of Figure 2;

Figures 10 and 11 represent functions of step number conversion means and frequency counting means respectively illustrated in Figure 9;

30 Figure 12 is a flow chart representing the operation of the second variation illustrated in Figure 9;

Figure 13 is a flow chart representing the operation of a modification of the second variation illustrated in Figure 9;

Figure 14 is a circuit diagram showing a third

variation of the focus determining system of Figure 2;

5 Figure 15 is a flow chart representing the operation of the third variation illustrated in Figure 14;

10 Figure 16 is a block diagram of part of a modification of the third variation illustrated in Figure 14; and

 Figure 17 is a flow chart representing the operation of this modification.

15 Referring initially to Figure 1, a focus determining system according to the invention comprises a light emitting element 1 and a light receiving element 2 disposed at a predetermined distance L from one another. The light emitting element 1 is actuated repeatedly to emit bursts of light on signals from a drive circuit 4, which is under the control of a micro-computer 3. The
20 light is directed at a subject S through a condenser lens 5, and the light reflected from the subject S is received by the light receiving element through a condenser lens 6 in the form of a spotlight. The effective position of the spotlight determines the range
25 of the subject and is represented by the electrical signals output from the element 2. These signals are converted into pulse width signals by a focus determining circuit 7 and supplied to the micro-computer 3, which then drives a focussing mechanism of a pick up
30 lens A through a pulse motor M .

 Figure 2 shows this system in detail. The light emitting element 1 radiates the light in the direction of the optical axis of the camera lens through the condenser lens 5, emitting the light in a single shot a

pre-determined number of times at a selected time interval or, for example, a predetermined number of times every 10 milli-seconds or, for example, eight times following each signal from the drive circuit 4. The circuit 4 comprises transistors 41, 42 arranged to become conductive in response to a high level signal generated by the micro-computer 3, and thereby to output a charge stored by a capacitor 43 to the light emitting element 1.

The light receiving element 2 is situated at a focal position of the condenser lens 6 for receiving light coming in the direction of the optical axis of the camera lens. This element 2 is provided with a cathode terminal 2a and two anode terminals 2b, 2c and generates current signals I_1 , I_2 corresponding to the effective position of the spotlight.

Reference numerals 71, 72 denote head amplifiers for receiving signals from the light receiving element 2, from the anode terminals 2b, 2c respectively. These signals are amplified by means of amplifier 71a, 72a. Capacitors 71c, 72c are charged through amplifiers 71b, 72b to control transistors 71d, 72d for by-passing signals having a lower frequency component than the pulsating signal arising from the light emitting element 1, that is signals arising from extraneous light, thereby enhancing the dynamic range of the pulsating signal.

The reference numeral 73 denotes a logarithmic conversion circuit, which comprises an operational amplifier 73a for compressing logarithmically the current signal I_1 from one head amplifier 71, an

operational amplifier 73b for compressing logarithmi-
cally the sum $(I_1 + I_2)$ of the current signals I_1 , I_2
from the head amplifier 71, 72, and a differential
amplifier circuit 73c for producing the arithmetic
difference between signals $\log I_1$ and $\log (I_1 + I_2)$
from the operational amplifier 73a, 73b, thus
generating a current signal $\log I_1 / (I_1 + I_2)$ propor-

tional to the range of the subject. This signal is output to a logarithmic expander 75, consisting of a diode, through a voltage follower 74, which is enabled by a data hold signal generated by the micro-computer.

- 5 The logarithmic expander 75 outputs a current signal $I_1 / (I_1 + I_2)$ proportional to the range to a double integrating circuit 76 which is described below.

The double integrating circuit 76 comprises an operational amplifier 76a, and an integrating capacitor 10 76b having a capacitance suitable for storing the current signal superposed N number of times, or eight times in the present embodiment. The capacitor 76b is arranged to receive the current signal through a switch S1 turned on by the aforementioned data hold signal, and 15 to receive current from a current source 77 through a switch S2 turned on by a read signal from the micro-computer 3.

The reference numeral 78 denotes a pulse width conversion circuit for producing a pulse having a width 20 proportional to the time required for charging the capacitor 76b of the double integrating circuit 76 up to a constant potential V_0 following the supply of the read signal. This pulse is output to the micro-computer 3 through AND gate 79.

25 The micro-computer 3 comprises a circuit 31 for controlling a focus determining operation by executing a series of steps as shown in the flow chart described below upon receipt of a signal from a focus determining switch B inter-locking with the camera release button.

30 An A/D conversion circuit 32 converts the pulse constituting a composite range signal from the focus determining circuit 7 into a digital signal under the control of a clock 32a, and an arithmetic operation circuit 33 converts the digital signal into range

information and thereby controls the pulse motor. The circuit 33 comprises a memory 33a and calculation means 33b.

Next, operation of the system will be described with reference to the timing chart given in Figure 3 and the flow chart given in Figure 4.

On turning on a range finding power source of the camera, a voltage arising from the extraneous light incident on the light receiving element 2 is stored on the capacitors 71c, 72c, and a current representing such extraneous light is by-passed to ground through the transistors 71d, 72d. At the same time, the integrating capacitor 76b receives current from the current source 77 through the switch S2 and is charged to the initial potential V_0 .

Then, if the focus determining switch B is turned on by operation of the camera release button with the camera pointing toward a subject, a light emission or fire signal for the first shot of light is generated from the control circuit 31. This actuates the light emitting element 1 through the drive circuit 4 to radiate light on the subject. The light reflected from the subject is transformed into a spotlight by the condenser lens 6 and is then incident on the light receiving element 2. Thus, the element 2 outputs a current relating to the effective position of the spotlight through each of the terminals 2b, 2c. Since the current signal is smaller than a time constant of the head amplifiers 71, 72, it passes therethrough and is compressed logarithmically into a range signal by the logarithmic conversion circuit 73. The control circuit 31 outputs the data hold signal at the point when a predetermined time ΔT_1 has elapsed after start of the light emission, namely the point in time when the range

signal has stabilised, whereby the logarithmic signal is output to the logarithmic expander 75 through the voltage follower 74 to convert it into a current signal. This current signal is input to the integrating circuit
 5 76 for a predetermined time ΔT_2 through the switch S1. Thus, the potential of the integrating capacitor 76b is lowered from the initial potential V_0 by ΔV_1 .

When the first light emission is over, the fire signal is interrupted to allow the light emitting
 10 element 1 to cool off and prepare for the next emission.

When a set interval ΔT_3 has passed after commencement of the fire signal, the control circuit 31 generates a further fire signal to actuate the light emitting element 1 again for radiating light on the same
 15 subject. Thus, a further current signal representing the range of the subject is generated from the light receiving element 2, and the current signal is converted into a further range signal by the logarithmic conversion circuit 73, then expanded logarithmically in
 20 response to the data hold signal and supplied to the capacitor 76b for the predetermined time ΔT_2 through the switch S1. The capacitor 76b integrates the second range signal with the first range signal and thus lowers the potential overall by an amount $\Delta V_1 + \Delta V_2$.

25 The light emitting element 1 is actuated at each interval ΔT_3 likewise thereafter for a predetermined number N of times to integrate the range signals and lower the potential on the capacitor 76b by an overall amount $\Delta V_1 + \Delta V_2 + \dots + \Delta V_n$. Whenever charging
 30 has occurred a predetermined number of times, the control circuit 31 generates the read signal to turn the switch S2 on and charge the capacitor 76b with a predetermined current from the current source 77. The time ΔT_4 required for the charging is proportional to the

charge $\Delta V_s = \Delta V_1 + \Delta V_2 + \dots + \Delta V_n$ accumulated in the capacitor 76b, and therefore a pulse of width ΔT_4 indicates the sum of the range signals N times. In the focus determining process, if there arises a miss in the operation due to the influence of extraneous light, then such influence will only affect (1/N) of the process.

The pulse signal is converted into a digital signal by the A/D conversion circuit 32, and is stored in the memory 33a then divided by the number of emission times N by the calculation means 33b to produce a mean value, converted, where necessary, into a step number corresponding to the camera. This value is employed for controlling the pulse motor M for driving the focussing mechanism.

In this embodiment, the whole data is divided by the number of light emission occurrences in the determining operation. However, since the number of light emission occurrences is constant, it is apparent that a similar result may be obtained by taking an integration signal from the capacitor 76b straight, or a value produced by dividing by a constant number M, as range information.

Thus, as described above, the light emitting element is actuated more than one time during each range finding period, and range signals produced on each emission are integrated so that the effect of an error in the data obtained on any light emission is minimised by averaging the information thus obtained and range information having a high reliability results. Also, the time for converting the integrated signal into a digital signal is not required by integrating in the state of range signal current, thus enhancing the speed for repeating the focus determining operation.

In a modification of the circuitry shown in Figure 2, the capacitor 76b of the double integrating circuit 76 has a capacitance suitable for storing each current signal rather than the superposed current signals. Each current signal is then converted into a digital range signal in the same manner as before, and the arithmetic operation circuit 33 is arranged to add the digital signals and transform the added result into range information for controlling the pulse motor.

Operation of this modification will be explained with reference to Figures 5 and 6. Only the parts of the operation which differ from the operation already described will be mentioned.

In this instance, when the first light emission is over, the fire signal is interrupted to allow the light emitting element 1 to cool off and prepare for the next emission, and at the same time the control circuit 31 generates the read signal to turn on the switch S2. The capacitor 76b is thus charged with a constant current from the current source 77. The time Δt_1 for the charging is proportional to the charge ΔV_1 accumulated in the capacitor 76b, and therefore the pulse of width Δt_1 output from the focus determining circuit 7 represents the initial analog range signal. This pulse is converted into a digital range signal by the A/D conversion circuit 32 and is then loaded into the memory 33a of the arithmetic operation circuit 33.

When the set interval ΔT_3 has passed, the integrating capacitor 76b receives current from the current source 77 through the switch S2 and is re-set to the initial potential V_0 . The control circuit 31 generates the second fire signal to actuate the light emitting element 1 and again irradiate the same subject. A further current signal representing the range of the

subject is generated by the light receiving element 2, and is converted into a further analog range signal by the logarithmic conversion circuit 33 and, after being expanded logarithmically, is supplied to the capacitor 76b for the predetermined time ΔT_2 through the switch S1. The potential of the capacitor 76b is thus lowered by an amount ΔV_2 corresponding with the analog range signal, and a pulse having a width Δt_2 is generated.

The light emitting element 1 is then actuated at each interval ΔT_3 likewise thereafter for a predetermined number N of times in total, and the analog range signals converted into digital range signals are loaded into the memory 33a of the arithmetic operation circuit 33. When the predetermined number N of light emissions is complete, the control circuit 31 actuates the arithmetic operation circuit 33 for digitally computing a mean value from the stored range data, or for converting such data into a step number corresponding to the camera as occasion demands for controlling the pulse motor M.

Thus, if a miss arises once or twice during the focus determining operation, such a miss will only affect $(1/N)$ of the process and so highly reliable range information is obtainable.

In this modification, each analog range signal is converted into a digital range signal before addition and so the integrating circuit can have a small linearity range and a reduction in cost can be realised.

Turning now to Figure 7, a first variation of the circuitry shown in Figure 2 is illustrated. Like parts are indicated by the same reference numerals and need not be described further. It should be noted that the focus determining circuit 7 in this instance is designed to operate in the same way as the modified focus deter-

mining circuit 7 from Figure 2 and the integrating capacitor 76b therefore has a capacitance capable of storing only a single analog range signal.

The main distinction in the circuitry of Figure 7 lies in the arithmetic operation circuit 33 which, in this variation, comprises memory means 33a in which each digital range signal is loaded, extreme value eliminating means 33b for receiving the digital range signals from the memory means 33a at the end of a focus determining operation and for providing as output those digital range signals apart from the two signals representing a maximum range for the subject and a minimum range for the subject respectively, adding means 33c for adding the digital range signals from the means 33b, dividing means 33d for calculating a mean value for the range of the subject by dividing this total value by the number $(N - 2)$, and step number conversion means 33e for converting the result into a step number for output.

The operation of these components will now be described with reference to the flow chart shown in Figure 8.

Each pulse output from the focus determining circuit 7 is converted into a digital range signal by the A/D conversion circuit 32 and is loaded in the memory means 33a of the arithmetic operation circuit 33. When a predetermined number N of such signals have been loaded successively into the memory means 33a, the control circuit 31 actuates the extreme value eliminating means 33b so that the digital range signals other than those representing the maximum and minimum values respectively for the range of the subject are supplied to the adding means 33c. These means 33c compute a total value from the received signals and

supply this value to the dividing means 33d, which
5 calculate a mean value for the range of the subject by
dividing the total value by 2. The control circuit 31
then actuates the step number conversion means 33e, as
occasion demands, for converting the mean value into a
10 step number corresponding to the camera for controlling
the pulse motor M for driving the focussing mechanism.
Thus, if an abnormal value is represented in the memory
means 33a due to a miss arising once or twice during the
focus determining operation, the digital range signal
15 representing that abnormal value will be excluded from
the calculation of the range of the subject so that
range information which is highly reliable will be
obtained.

In this embodiment as described, the abnormal
value is discriminated at the end of the focus deter-
20 mining operation. However, it is equally possible to
monitor for abnormal values in parallel with the focus
determining operation.

Next, a second variation of the focus determining
system of Figure 2 will be described with reference to
25 Figures 9 to 12. As before, like parts are represented
by the same reference numerals, the focus determining
circuit 7 produces an output pulse in response to every
analog range signal, and only the parts differing from
those previously described will be explained.

30 The main distinction is in the arithmetic
operation circuit 33, which comprises memory means 33a,

and step number conversion means 33b providing a
directory with clock numbers within specified ranges
 $C_0 - C_1$, $C_1 - C_2$, ... $C_6 - C_7$ as addresses and step
numbers S_0 , S_1 , ... S_7 as corresponding data values as
shown in Figure 10. The digital range signals loaded

in the memory means 33a from the A/D conversion circuit 32, that is the clock values, are checked against the ranges in the step number conversion means 33b for converting the signals into step numbers. The arithmetic operation circuit 33 also comprises frequency counting means 33c provided with a step number counter as shown in Figure 11 for monitoring the frequency with which the various step numbers occur.

The operation of these components will now be described with reference to the flow chart given in Figure 12.

Firstly, each pulse received by the A/D conversion circuit 32 is stored in the memory means 33a as a respective digital range signal. Each such signal coming within a fixed range is converted in the step number conversion means 33b into a step number, the step number being calculated with precision practically regardless of errors caused in the focus determining circuit. Each step number is loaded in the frequency counting means 33c.

When a focus determining operation is complete, the control circuit 31 reads the most frequently occurring step number from the frequency counting means 33c as range information, and controls the pulse motor M accordingly.

Thus, step numbers obtained erroneously are eliminated, and highly reliable range information is obtainable.

In the variation just described, the most frequently occurring step number is supplied as range information after N light emissions have taken place and the focus determining operation is over. However, turning to Figure 13, it is possible in a modification to load the step numbers successively into the frequency

counting means 33c, and at the point where one particular step number has occurred a predetermined number of times, for example three times, the focus determining operation is terminated before the predetermined number N of light emissions have taken place and the step number in question is employed as range information. Under good conditions, therefore, the number of light emissions needed for range finding can be decreased and yet highly reliable range information can still be obtained even in cases where the environmental conditions are unfavourable.

A third variation of the focus determining system of Figure 2 will now be described with reference to Figures 14 and 15. Again, like parts are represented by the same reference numerals and will not be described. The circuitry shown in Figure 14 also operates on the basis that the capacitor 76b stores only a single analog range signal and that the focus determining circuit 7 outputs a pulse for each analog range signal.

In the circuitry of Figure 14, the arithmetic operation circuit 33 comprises memory means 33a capable of storing a plurality of the digital range signals, and perspective decision means 33b for judging whether the range represented by these signals is "short" or "long" by comparing these signals with a reference value. The circuit 33 further comprises mean value computing means 33c for calculating a mean value from the digital range signals, and step number decision means 33d for transforming the calculated result into a step number.

Operation of these components is illustrated in Figure 15. The digital range signals output by the A/D conversion circuit 32 are successively loaded in the memory means 33a. When a predetermined number N_1 of

these signals have been loaded, that is when a predetermined number N_1 of light emissions have occurred, the control circuit 31 causes this number of the digital range signals to be supplied from the memory means 33a to the perspective decision means 33b for a decision as to whether the range represented is "short" or "long".

Where the decision is that the range is "short", this means that a significant proportion of the light radiated by the light emitting element 1 is received back by the light receiving element 2 and so the output from this element is likely to have a high reliability. Therefore, the focus determining operation is discontinued thereafter and the digital range signals currently loaded in the memory means 33a are supplied to the mean value computing means 33c for calculation of a mean value. This mean value is then transformed in the step number conversion means 33d into a step number for output.

On the other hand, where the decision is that the range is "long" or the result is uncertain in that the digital range signals represent "long" and "short" ranges irregularly, the focus determining operation is continued further and further digital range signals are loaded into the memory means 33a.

When the new number of digital range signals in the memory means 33a reaches a further predetermined number N_2 ($N_2 > N_1$), the control circuit 31 reads the signals loaded in the memory means 33a and obtains a mean value of these signals from the mean value computing means 33c. This mean value is then transformed into a step number for output.

Thus, if the light reflected from the subject is not intensive and a miss arises once or twice during the focus determining operation, each miss only has a

($1/N_2$) effect on the overall result and range information of a relatively high reliability is still obtainable.

A modification of the circuitry of Figure 14 is shown in Figure 16 wherein the reference numeral 34 denotes the arithmetic operation circuit for receiving digital range signals from the A/D conversion circuit 32. The circuit 34 comprises step number conversion means 34a as previously described with reference to Figures 9 and 10 and the step number conversion means 33b shown in Figure 9. The circuit 34 further comprises memory means 34b for storing the step numbers generated by the step number conversion means 34a, and identity decision means 34c for judging the consistency of the step numbers once a number N_1 of these numbers have been stored in the memory means 34b. Extreme value elimination means 34d are also provided for excluding maximum and minimum step numbers loaded in the memory means from the output, and mean value computing means 34e are provided for obtaining a mean value from the step numbers.

The operation of these components is shown in Figure 17.

The signal output from the focus determining circuit 7 when the focus determining operation is started is converted into a digital range signal, then transformed into a step number by the step number conversion means 34a and loaded into the memory means 34b. These steps are repeated until a number N_1 of step numbers are loaded in the memory means 34b, whereupon the step numbers are read out of the memory means

34b and the consistency of the step numbers is judged by
5 the identity decision means 34c.

If there is identity amongst the step numbers,

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then it is assumed that the focus determining operation has been accurate so far and the operation is discontinued. The single step number is then supplied as an output.

5 On the other hand, if there is a discrepancy between the step numbers, the focus determining operation is assumed to be low in reliability and is continued further until a number N_2 ($N_2 > N_1$) of step numbers are loaded in the memory means 34b. When this
10 number is reached, the step numbers are read out to the extreme value eliminating means 34d and the ones which remain after the maximum and minimum numbers have been excluded are averaged by the mean value computing means 34e for providing the range information. In this way,
15 range information which is highly reliable can be obtained and unreliable data is excluded.

Thus, a decision as to whether or not to continue a focus determining operation after a predetermined number of step numbers have been provided is judged
20 according to the identity of these numbers. Therefore, power consumption can be minimised in that the number of light emissions can be reduced when the results indicate that accurate analog range signals are being obtained. Equally, reliable range information can still be
25 obtained by increasing the number of light emissions when errors are more likely to occur in the processing of each light emission.



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1. A focus determining system for a camera, comprising a light emitting element and a light receiving element, means for controlling the light emitting element to emit in a single range finding operation a pre-determined number of bursts of light for irradiating a subject, the light receiving element being arranged to generate a respective range finding signal in response to light reflected from the subject during each burst of emitted light, means for integrating each range finding signal, and means for deriving a mean value for the range of the subject in response to an output of the integrating means.

2. A focus determining system as claimed in claim 1, in which the integrating means are arranged to generate a single output signal for supply to the deriving means following integration of a plurality of the range finding signals.

3. A focus determining system as claimed in claim 1, in which the integrating means are arranged to generate a respective output signal for supply to the deriving means following integration of each respective range finding signal.

4. A focus determining system as claimed in claim 3, in which the deriving means comprise means responsive to the output signal of the integrating means for supplying digital range signals, and means for adding the digital range signals.

5. A focus determining system as claimed in claim 4, in which the deriving means further comprise means for



inhibiting digital range signals representing a maximum range and a minimum range respectively from reaching the adding means.

6. A focus determining system as claimed in claim 3, in which the deriving means comprise means responsive to the output signals for generating step numbers representative of selected values for the range of the subject.

7. A focus determining system as claimed in claim 6, in which the deriving means further comprise means for selecting a value for the range of the subject on the basis of the frequency of occurrence of each step number.

8. A focus determining system as claimed in claim 7, in which the selecting means are arranged to select the value for the range of the subject represented by the most frequently occurring step number.

9. A focus determining system as claimed in claim 7, in which the selecting means are arranged to select the value for the range of the subject represented by a step number which occurs a predetermined number of times, and in which means are provided for terminating the range finding operation when a step number has been selected.

10. A focus determining system as claimed in any of claims 1 to 8, further comprising means operable after a predetermined number of emissions of the light emitting element to assess the accuracy of the range finding signals, and means controlled by the assessing means for terminating the range finding operation.

11. A focus determining system as claimed in claim 10,



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5 in which the assessing means are arranged to judge
whether the range finding signals represent a short
range or a long range and are arranged to assess the
accuracy on this basis.

12. A focus determining system as claimed in claim 10,
in which the assessing means are arranged to judge the
10 consistency of the range finding signals and are
arranged to assess the accuracy on this basis.

13. A focus determining system substantially as herein
particularly described with reference to and as
illustrated in the accompanying drawings.

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