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A RADIO TRACKING SYSTEM FOR THE BLACK RHINOCEROS

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ABSTRACT:

The need to gain more knowledge of the biology and ecology of the black rhinoceros prompted the development of a radio tracking system for the species in Hluhluwe Game Reserve. The posterior horn was selected as the site for the installation of a radio transmitter in preference to the anterior horn. This transmitter was placed in a hole drilled in the horn, whilst the loop aerial was embedded in a groove; the whole apparatus was sealed with fibre glass. On account of the nature of the topography in the study area it was possible to locate the study animals very accurately with a horizontal, two-element Yagi antenna mounted on the front of a four-wheel drive vehicle. Plotting of the positions was carried out by triangulation, with the help of a fixed beacon transmitter.

INTRODUCTION

During the course of a comprehensive study of the black rhinoceros *(Diceros bicornis* Linn.) it was desirable to locate individual animals at frequent intervals. However, this was seldom possible since the nature of the study area made visual observations quite difficult. It is situated in the north-eastern section of Hluhluwe Game Reserve and varies in altitude between 107 and 378 metres above sea level. Most of the area is comprised of woodland and dense thickets with patches of riparian and semi deciduous forest. The tops of numerous ridges are covered by a lightly wooded tree savanna (Hitchins 1969).

On account of the difficulties experienced in locating individual rhinoceroses, use is now made of radio tracking equipment which is ideally suited to the hilly terrain and the extensive road system of 36 km in the study area.

Several rhinoceroses equipped with small radio transmitters are tracked on a routine basis using a radio receiver and an accurate direction-finding antenna mounted on a vehicle.

This paper describes theoretical and practical work which resulted in the implementation of a successful tracking system. The method of attachment of the transmitter and its antenna to the animal is considered to be a new approach. Furthermore, some novel features are included in the direction-finding equipment.

THEORETICAL CONSIDERATIONS

On account of the habits of the black rhinoceros such as wallowing in mud and rubbing against trees, careful thought had to be given to the method of attachment of the transmitter to the animal.

The use of a harness is precluded by the habits of the animal and its tremendous strength. If made strong enough, it will be uncomfortable to the animal and probably influence its habits.

The shape of the animal's neck and head makes it impossible to use any form of neckband since this will undoubtedly slip over its head and fall to the ground.

After careful consideration it was concluded that the only solution worth investigating would be to embed the transmitter and its antenna into the posterior horn of the animal. It was considered that a hole could be drilled painlessly into the horn which has a filamentous structure (Ryder 1962) originating from the epidermis and is supported on the nasal bones of the skull.

The anterior horn, although larger and therefore capable of housing a larger, more powerful transmitter, is the animal's main weapon and it was thought unwise to tamper with it in any way. It was thought that the transmitter could be imbedded to a sufficient depth at the base of the horn to avoid exposure due to rubbing and horn growth.

It was envisaged that a transmitting antenna in the form of a loop could also be embedded, lying in a circumferential groove cut into the horn and that the transmitter and antenna could then be covered with glass-fibre and resin which would form a watertight seal with the horn and afford excellent protection for the transmitter.

A two year period was considered adequate for this investigation and although animals can be operated upon more than once if necessary, it would be an advantage if the service life of the transmitters and their power supplies were sufficient to make renewal unnecessary.

Part of the work would consist of studying the territorial behaviour of these animals by regularly plotting their positions on a map without necessarily observing them visually. Time would be saved if the location of a number of animals could be established by radio-tracking them from a few fixed observation points around the study area from a distance of some 3 km. It was considered sufficiently accurate for the purpose to be able to define an area of $\frac{1}{4}$ km by $\frac{1}{4}$ km within which the animal must be located. This means in effect that an angular accuracy of plus and minus $2\frac{1}{2}$ degrees would have to be achieved in the directional measurements.

Occasionally, visual observation would be required and greater accuracy could then be ensured by taking further bearings from points lying adjacent to the area of uncertainty defined by the initial measurements. Thereafter it should be possible to leave the vehicle and find the animal using a hand-carried receiver and directional antenna for guidance.

EXPERIMENTAL INVESTIGATIONS

A. Procedure for installing the transmitter

The proposed method of mounting the transmitter was tested on two horns in the laboratory. The hole was readily drilled using a blade type bit and the groove formed using a cutter in an electric hand drill. The material of the horn proved to be very tough but the entire operation was completed within about 30 minutes using these power tools.

A dummy transmitter case made out of brass was then put into the hole and a loop of 1 mm diameter copper wire was laid in the groove. This single-turn coil was then tuned to resonance at the proposed operating wavelength and measurements were made of the circuit of Q and the capacitance required for resonance. The hole and groove were then covered with Pratley putty and these measurements repeated at intervals as indicated in Table 1. After the putty had set hard, a wet towel was wrapped around the horn to soak it and create surface conditions similar to those which may be expected subsequent to wallowing. The glass-fibre and polyester resin used to cover the hole and groove formed a strong bond with the surface of the horn.

Over a period of three months neither animal showed signs of wear or damage to the glass-fibre and it was concluded that the proposed method would be satisfactory. The indications were that the transmitter should preferably not exceed 22 mm diameter by 40 mm length, but a length of 60 mm would be permissible. Many animals have horns of sufficient size and a loop length of 25 cm can usually be accommodated. These dimensions may therefore be used for design purposes.

TABLE 1 **Measurements on loop antenna around horn.**

CONDITION	Q	C PF	Elapsed time in minutes
Loop in air	320	13.0	
Loop in groove around horn	120	12.8	
Loop in groove and transmitter case in hole	115	13.0	
Ditto but transmitter and loop covered with Prattley putty	70	12.9	0
Putty still quite soft	87	12.9	40
Putty fairly hard	107	12.9	270
Putty completely set	109	12.9	400
Wrapped in damp towel, thereafter towel removed	99	12.8	420
After drying normally in air for 100 minutes	105	12.9	520

Table I shows that quite high Q values were obtained with the horn inside the loop and that the effect of the putty was small and constant once the putty had set. Moisture on the surface of the horn only had a small, temporary effect. Later, glass fibre and quick setting resin were used and the setting time reduced to about 30 minutes. The electrical constants of the embedded loop were near the previous values.

It was therefore concluded that the presence of the horn would only cause a moderate loss of power and that a reasonable radiation efficiency (considering the size of the loop) could be expected.

The next step was to dispatch dummy transmitters to the Hluhluwe laboratory of the Natal Parks, Game and Fish Preservation Board to verify the proposed method. Tests were carried out on two animals, one a white rhinoceros in captivity which could be observed continuously, the other a black rhinoceros which was frequently seen in its natural environment.

The entire operation was performed within $1\frac{1}{4}$ hours including the immobilization of the rhinoceros, a procedure used by the Natal Parks Board for translocation purposes (Keep, Tinley, Rochat and Clark 1968). It was found no more difficult to perform the drilling and grooving operations in the field, using a portable petrol-electric generating plant as a source of power for the electric drill, than working on a dead horn in the laboratory. The

B. A double Yagi antenna for accurate directional measurements

Experience gained with a project described by Anderson and de Moor (197[illegible]) showed that the required accuracy of ± $2\frac{1}{2}$ ° would hardly be realised using a normal 4 element Yagi antenna. A loop antenna provides a sharply defined directional indication of a signal minimum but cannot be used with horizontally polarized waves and is not sufficiently sensitive for long range work. It was necessary to find a more suitable type of antenna. The decision to use horizontal polarization was dictated by the direction in which the plane of the transmitting loop would normally lie. Also, parts of the study area are covered by dense vegetation which was known to have a greater effect on vertically polarized waves.

To obtain better azimuthal accuracy, the horizontal dimensions of an antenna have to be increased. Marshall (1963) used a double Yagi on a wavelength of 2 metres but was unable to resolve the ambiguities caused by minor lobes in the polar diagram. Cochran et al. (1965) used a large antenna consisting of 2 five-element Yagi's spaced 2 wavelengths apart horizontally. This antenna provided an accuracy of approximately $\frac{1}{2}$°. At this spacing the major lobe of the polar diagram is quite narrow but important secondary lobes appear on both sides of the main lobe and care is required to avoid confusion when using the antenna.

The literature consulted by the authors makes no mention of the possibility of using two Yagi antennae spaced such a distance apart that secondary lobes will all be below a prescribed limit, for instance below the strength of the unavoidable back lobe which is typically 12 dB below the main forward lobe. This condition prevails when the spacing between Yagi centres is from $\frac{1}{2}$ to $\frac{3}{4}$ of a wavelength. The approximate shape of the resulting polar diagram for the sum of the signals of a pair of two-element Yagi's spaced $\frac{3}{4}$ wavelength is shown in Fig. 1 a. Confusion is impossible provided that the antenna is swung over the entire 360^{o} in order to locate the forward maximum.

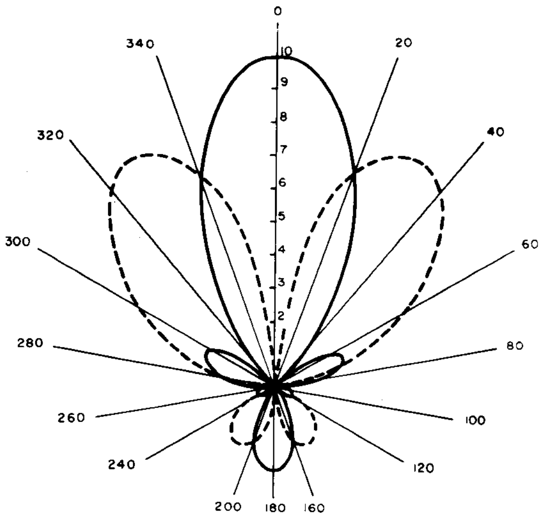


Fig. 1

Typical polar diagrams of a pair of two element Yagi antennae spaced $\frac{3}{4}$ wavelength horizontally.
(a) —— sum of signals, (b) – – difference between signals.

Once the approximate direction of the forward maximum has been determined, a device is used which improves the directional accuracy by a large factor. If, instead of adding the signals from the two Yagi's, these are subtracted, a null is produced in the forward direction. In this direction the two Yagi's are at equal distances from the transmitter and, if carefully constructed to be electrically identical, will produce equal signals which are also in phase with one another. Vector subtraction therefore produces a null. The change-over from the sum to the difference condition is readily achieved electrically and the maximum or minimum signals are accurately indicated by the signal strength meter of the receiver.

The polar diagram of the array, connected to produce a difference signal, is shown in Fig. 1b. It will be noted that there is now a main lobe on both sides of the forward direction. Note also that if a signal is received in the sum condition at 10dB signal-to-noise ratio, then using the difference condition, the signal-to-noise ratio will drop to 0dB (signal barely detectable) when the antenna is swung to point in a direction only 9 degrees off the true direction to the transmitter. Obviously, with stronger signals still, a very small rotation away from the null point will bring back the signal. In practice with a 20dB signal-to-noise ratio, it was found that even an inexperienced operator required only 10 seconds to perform a directional measurement with an accuracy of approximately 1 degree.

C. A transmitting beacon to provide a reference direction.

In order to transfer antenna bearings to a large scale map of the area, a directional reference has to be provided against which the azimuthal angles may be read off. Whilst this can be done using a magnetic compass, the direction in which the polar diagram of the antenna falls is not accurately known relative to its mechanical axis since this depends on the electrical symmetry of the pair of Yagi's. Furthermore the magnetic effect of the vehicle has to be taken into account if accurate compass readings are required. The setting up procedure at each point of observation soon becomes a monotonous and time consuming chore.

A very effective solution to this problem has proved to be the erection of a transmitting beacon on a known high point which is within line-of-sight from all observation posts within the study area. The receiving antenna is then directed at the beacon and this direction used as a reference. A graduated scale at the base of the antenna can be set to zero when aiming at the beacon and thereafter the azimuth angle of the animal is read directly from this scale and marked off on the map relative to the line that joins the observation point with the location of the beacon. Any directional errors which may be present in the antenna will tend to cancel when following this method.

The use of one or more such beacons (depending on the size and topography of the terrain) is strongly favoured. Siting these to provide line-of-sight conditions ensures adequate signal strength and directional accuracy throughout the study area.

EQUIPMENT

A. Transmitting Apparatus

(i) Rhino transmitter

This is based on the design used with Vervet monkeys (Anderson and de Moor 197[illegible]) but uses smaller components. Some values were changed to improve overall efficiency when, as in this case, the load on the loop is light.

As a result of the smaller case diameter called for in the specifications, a different cell type had to be chosen. The Mallory mercury RMIN which is specially manufactured for use in low-drain long-life applications, has a 1 Ampere hour capacity so that a 20,000 hour life will be obtained if the average current drawn is 1/20,000 A = 50 microamps. By incorporating the circuit changes mentioned above, this low drain was obtained with no decrease in the R. F. voltage present across the loop antenna.

The transmitter loop is a 1 mm diameter copper wire enclosed in a thick-walled plastic tube which allows thermal expansion of the wire without endangering the covering material. The tube also protects the wire against chemical attack from materials in the horn. The wire is soldered to two terminals located on the insulated cover of the transmitter case which itself is made of brass and is sealed to the cover.

The transmitter circuit diagram is shown in Fig. 2. It will be noted that the base bias resistor R1 is connected to the collector of the oscillator transistor instead of to the positive side of the cell. Consequently the oscillator cannot draw current when the loop antenna is not connected and the rest of the circuit only draws some 4 microamps under these conditions. This means that the assembled transmitter with the cell connected may be left on the shelf for some years without appreciably draining the cell. Only one operation is required in the field to switch the transmitter on, namely to connect the loop. R1 has a high value therefore consuming a negligible fraction of the R. F. power.

Fig. 3 shows the components of the transmitter.

(ii) Beacon transmitter

A strong signal is an advantage when attempting to obtain accurate azimuth information as explained in section 3b, and since size and weight restrictions are not applicable in this case, a transmitter was constructed using the same basic circuit but drawing an average

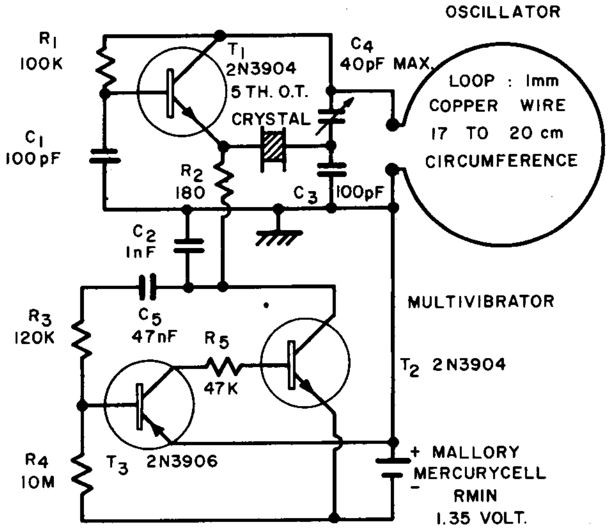


Fig. 2
Circuit diagram of transmitter used on rhinoceros.

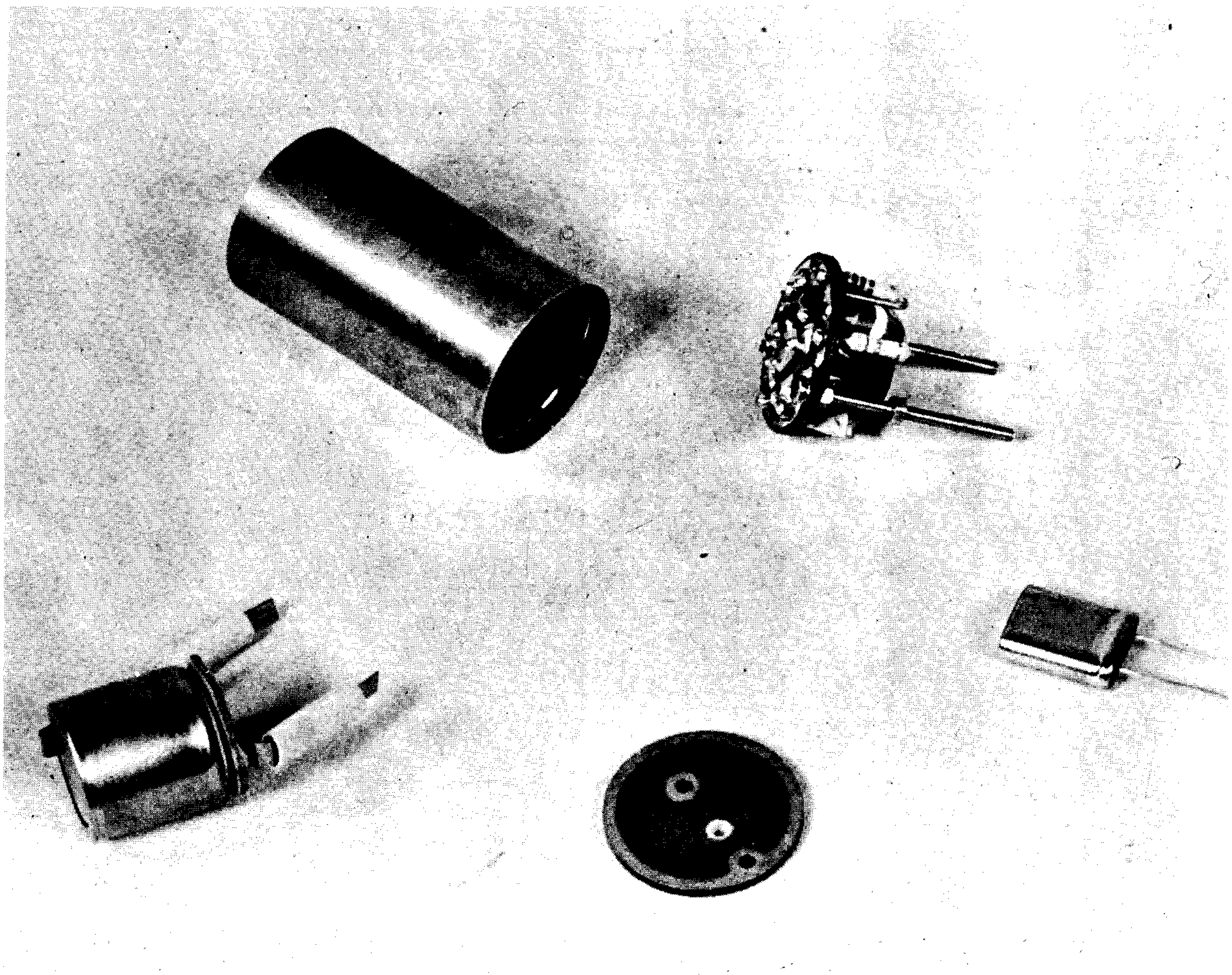


Fig. 3
Components of transmitter.

current of 160 microamps at 4.05 volts from 3 Mallory mercury ZM12 cells connected in series. These have a 3,6 amp-hour capacity and should last 22,000 hours ($2\frac{1}{2}$ years). In addition the transmitting loop has about 5 times the area of the animal transmitter loop and is matched to the transmitter by means of C_4 and C_6 (see Fig. 4) which increases the efficiency of D.C. to R.F. power conversion. These factors combine to produce a signal at least 100 times as strong as that of an animal-borne transmitter.

The transmitting loop was placed in a horizontal plane to produce the required polarization and omnidirectional coverage.

B. Receiving Apparatus

(i) Antenna

Fig. 5 gives details of the twin two-element Yagi used. It is supported at its centre on a telescopic mast made out of two sizes of square aluminium tubing, the inner sliding in a bush in the outer. The mast can be rotated by hand, turning lightly on ball-bearings fixed to the bumper of the vehicle. At the base a compass rose, which can be rotated and locked to the vehicle once the reference direction has been found, is provided.

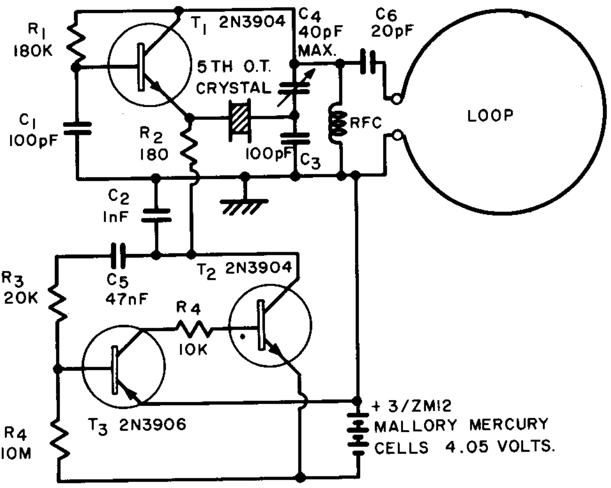


Fig. 4

Circuit diagram of beacon transmitter, RFC: 35 turns of 42SWG enamelled Copper wire wound on a $\frac{1}{4}$ W 1 M ohm resistor. Loop: Copper strip, thickness 1 mm, width 20 mm, length 33 cm plus body of transmitter case : 18 cm.

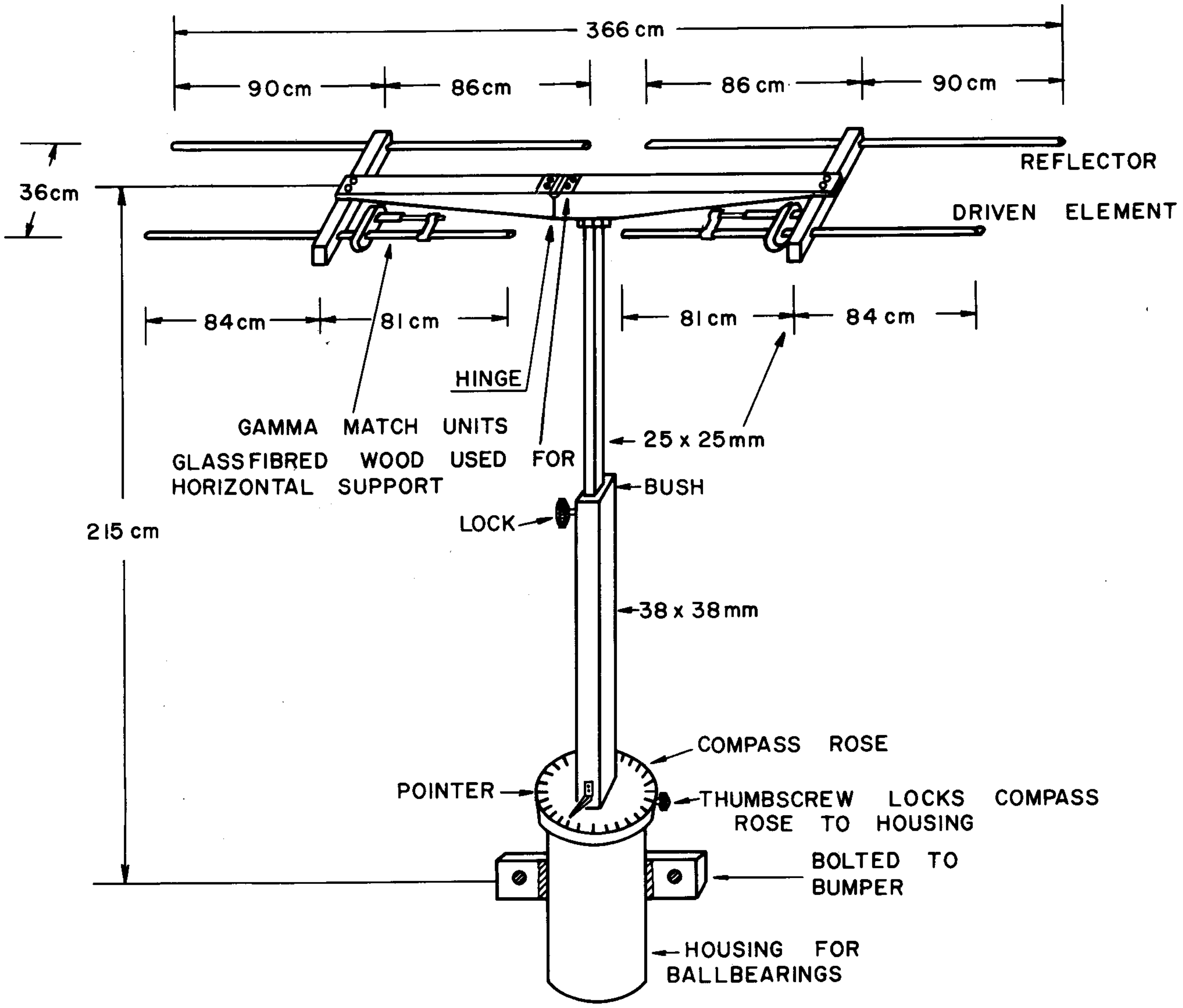


Fig. 5

Rotary twin two element Yagi.

A pointer fixed to the vertical support swings over this scale and indicates the angle through which the antenna has been rotated.

The distance between the outer tips of the Yagi elements is 366 cm which cannot easily be accommodated on a Land Rover. The horizontal support was therefore hinged at the centre so that one of the Yagi's may be folded over to lie flat on top of the other, the outer ends of the elements then resting in grooves in a wooden member bolted to the roof of the cab. In Fig. 6 the antenna is unfolded and hoisted to its operating position.

Since horizontal polarization is used, the antenna elements have to lie in a horizontal plane. In a compact antenna the horizontal support must of necessity lie between the elements and parallel to them. It has therefore to be made of non-conducting material not to influence the antenna. Unfortunately the feedlines still have to run from the centre of each Yagi to the centre of the array in order to be out of the way when the antenna is rotated. The presence of these conductors inside the field of the antenna as well as capacitive coupling between the inner ends of the Yagi elements give rise to unbalance. This was eliminated by shifting the elements in their individual booms to make their inner halves shorter than the outer halves as shown in Fig. 5.

Matching to the feedlines was done by means of gamma matching units as shown Fig. 7. These have built-in adjustable capacitors set to a suitable value by shifting the central rod. All dimensions shown should be taken as a guide only. They depend, of course, on the operating wavelength (3,55 metres in this case)

Fig. 6

Antenna opened and elevated into operating position.

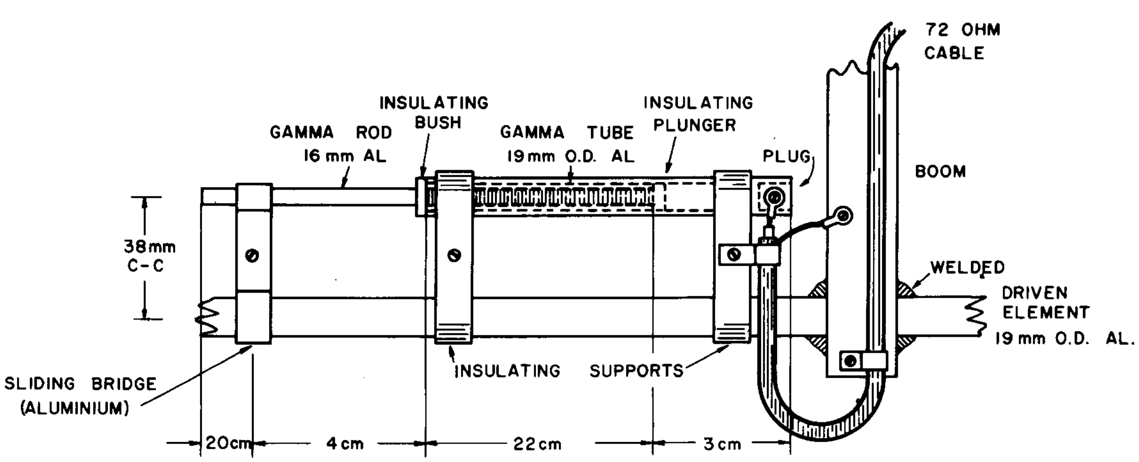
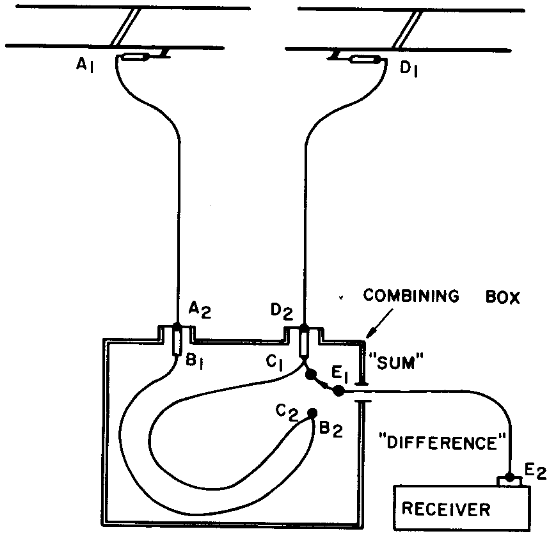


Fig. 7

Gamma matching unit connecting feedline to driven element of Yagi antenna.

and should be individually adjusted to give minimum standing-wave ratio at the operating wavelength in conjunction with adjustments of the gamma match. If the front-to-back ratio is not satisfactory, the length of the reflector elements has to be adjusted whilst using the antenna for receiving the signals of a transmitter placed at some distance from it. It is then usually necessary to make small readjustments to the other elements as well.



NB. BRAIDS OF ALL CABLES TO BE GROUNDED

Fig. 8

Details of feeder connections and combining circuit.

Fig. 8 shows the manner in which the Yagi signals are either added or subtracted. The cables running from the gamma-match units to the combining box (A_1 , A_2 and D_1 , D_2) should be equal in length to within 1 cm. Inside the box $\frac{1}{4}$ wave sections (B_1 , B_2 and C_1 , C_2) of the same impedance are added to the cables, their far ends being joined to give a point B_2 C_2 which is equidistant from the two Yagi's. With the gamma match units connected as shown in Fig. 8, viz., one to the left-hand side of a Yagi, the other to the right-hand side of the other Yagi, the signals produced when a wavefront advances along a perpendicular to the long dimension of the array will be in phase opposition at the top ends of the feedlines. Hence, after traversing equal lengths of cable, they will arrive at the bottom (joined) ends also in opposition. A signal equal to the vector difference between the two Yagi signals is therefore obtained at this point to which one pole of a selector switch is connected.

The other pole of this switch is connected to a point C_1 , $\frac{1}{4}$ wavelength up one of the two cables. Hence the distance to the top of that cable is shortened by $\frac{1}{4}$ wavelength whilst the distance to the top of the other cable is lengthened by $\frac{1}{4}$ wavelength, the total effect being that one signal is shifted by half of a wavelength relative to the other signal. In this position the switch then brings in the sum of the two Yagi signals.

All wavelengths referred to are, of course, electrical wavelengths which, for typical 72 ohm coaxical cable are about $\frac{2}{3}$ of the wavelength in air. For instance, if the operating wavelength is 3 metres a $\frac{1}{4}$ wave in air would be $\frac{3}{4}$ metre and in this cable it would be $\frac{2}{3} \times \frac{3}{4} = \frac{1}{2}$ metre.

When connecting two 72 ohm cables to a common point, the load resistance placed on that point should be $72/2 = 36$ ohms to terminate both cables correctly. Since the receiver input is 72 ohms, a $\frac{1}{4}$ wave matching section E_1 E_2 was used with an impedance of $\sqrt{72 \times 36} \doteq 51$ ohms. This connects the receiver to the selector switch.

(ii) Receiver

The receiver has been described by Anderson and de Moor (1970). Its main characteristics may be summarised as follows:

It is designed to be used as a portable receiver with built-in horizontal telescopic antenna which can be used to guide the observer when he follows the animal on foot in places inaccessible to a vehicle. It then uses built-in primary cells as power supply and draws 35 mA at 12 volts. There is a signal strength indicator giving clear readings on input signals between 0,1 and 1000 microvolts. Aural detection using a loudspeaker or earphones enhances the sensitivity by 14 dB as a result of the narrow bandpass of the ear (100 Hz) compared with the 2500 Hz bandpass of the main filter. The receiver can be switched to any one of 20 crystal controlled frequency channels spaced 10 kHz apart, one for each transmitter frequency.

Used as a mobile receiver, it can obtain its power from the vehicle accumulator and its signal from the twin Yagi which provides about 15 dB more sensitivity and much improved directional accuracy compared with the built-in antenna used at ground level.

INSTALLATION OF TRANSMITTER

With the antenna mounted on a Land Rover ready for use, a black rhinoceros was immobilized the morning of November 10, 1969, and its posterior horn was drilled and grooved as described. However, when the transmitter was placed in position it failed to operate. Experiments showed that the live horn was loading the loop antenna of 25 cm length excessively, and moisture in the horn, not present in the dead horns submitted for tests, was suspected. Electrical conductivity measurements on the horn confirmed this.

By reducing the loop length, the loading on the transmitter caused by losses in the material of the horn could be reduced. Furthermore, reducing the loop size necessitated increasing the capacitance of C_4 (see Fig. 2) to restore resonance and this produced more feedback in the oscillator which could then accept a heavier load.

It was therefore decided to restrict the loop circumference to between 17 and 20 cm in future and to place it higher up the horn in drier regions. The hole for the transmitter could then be drilled slightly downwards at an angle which removed it from the plane of the loop, thus increasing efficiency.

A second rhinoceros (C) was successfully equipped that same afternoon, the entire procedure working out as planned. After placing the transmitter in the hole and laying the loop in the groove, the end of the wire was soldered to the grounded terminal on the transmitter. A hole in the cover immediately above the trimmer was temporarily blocked with a brass plug which was given a liberal coat of silicone grease. Glass-fibre and resin were now applied to cover groove and transmitter without adhering to the plug which could easily be removed after the resin had cured. In so doing, a hole was left in the material giving access to the trimmer which was adjusted until the required signal was heard on the receiver standing nearby. Optimum setting of the trimmer depends on loop length and the dielectric constant of the material in and around the loop – hence the necessity of setting the trimmer at the end of the operation after the glass-fibre resin has cured.

Thereafter the trimmer hole was closed using a small screw and the hole in the glass-fibre marked by filling it with coloured wax. The entire surface was then given a final coat of glass-fibre and resin and allowed to cure before the animal was given the antidote, If, in future, the transmitter should require readjustment, the marked hole can easily be located and exposed by removing the glass-fibre over a small area. Figures 9, 10 and 11 show how the operation was performed, whilst Table 2 sets out the times taken by each phase of the first four installations.

6: INITIAL RESULTS

The latter part of the operation described above was done under an umbrella since it started raining. Rain continued all night and next morning but later that day the Land Rover was taken out and the animal successfully tracked to thick bush near the place where the operation had been performed. Next morning the animal was again tracked in clear weather. She had now moved in behind a hill and her signals were audible 2 km away and on a correct bearing when observed from the next hill. In closing in on the animal using the hand held set, high ground or dense vegetation intervened on several occasions and caused aberrant readings. This demonstrated the importance of mistrusting readings taken near such objects.

Subsequently the animal was located daily and its position plotted on a 1 : 10,000 map using the technique of angulation described in Section 3. To establish the exact positions readings were taken from two or more

TABLE 2.

Time (in minutes) taken to complete each operation

TRANSMITTERS	A	B	C	E
Drilling tramsmitter cavity	5	9	4	9
Cutting groove for antenna	7	6	2	6
Fitting transmitter and loop antenna	5	20	8	9
Initial fibre-glass covering	17	18	7	13
Tuning transmitter and sealing trimmer hole	5	4	6	10
Final fibre-glass covering	14	7	22	24
Time for entire operation including immobilization	114	121	104	140

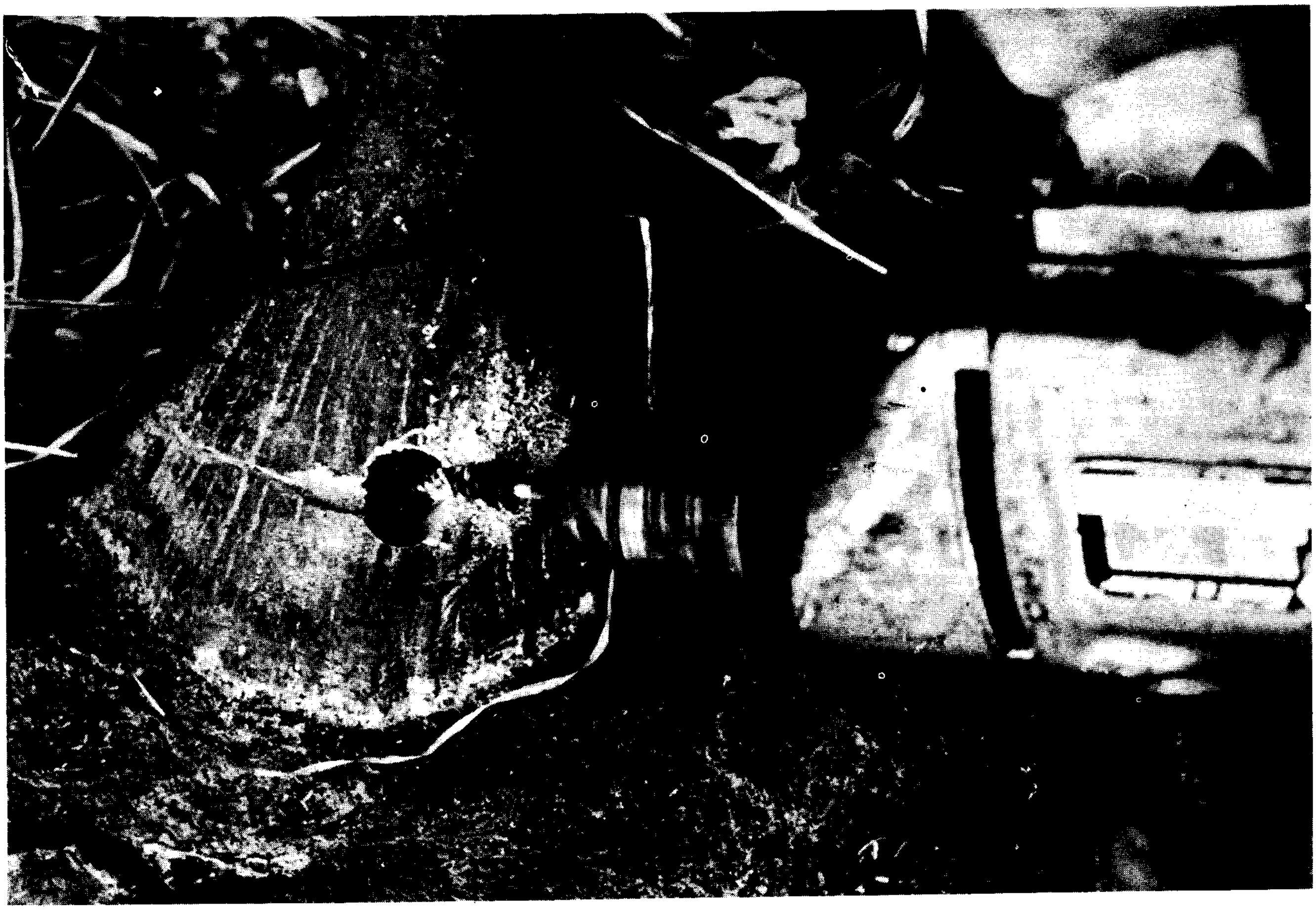


Fig. 9
Cutting a groove around the horn after the hole has been completed.

Fig. 10
With the transmitter in position, the loop antenna is laid in the groove ready for soldering.

Fig. 11

The transmitter and antenna have been covered with glass fibre and a final performance check is carried out using the receiver.

stations. The intersection of lines drawn on the map indicated the position of the animal. On December 8 the transmitter stopped and it was not before January 12 that the opportunity presented itself to immobilize the animal once more. It was then discovered that the final layer of glass-fibre had failed to bond with the lower layer (possibly because of rain wetting the surface during the initial operation). It had splintered off and left the tuning hole exposed to become clogged with moist debris. When this was cleaned out, the transmitter restarted. This time the surface was thoroughly dried and a liberal layer of glass-fibre applied. To date the signal has not failed again.

The second rhinoceros to be tagged (A) was a male; the operation was performed on November 13 and the signal has been consistently good.

The third, also a male (B) was the same animal into whose horn the dummy transmitter had been placed 116 days prior to the date of this operation which was December 4, 1969. The horn was in excellent shape with no sign of wear on the fibre-glass. For some unknown reason the pulse rate of this transmitter decreased gradually until pulsing stopped on December 25 in the "on" condition. Although disappointing, this failure did not prevent tracking and constituted an accelerated life test of the RMIN cell. The continuous signal stopped after 2½ months – the anticipated period.

The fourth transmitter was put into the horn of a female (E) on January 12, 1970. On awakening from sedation the animal charged and made contact with a vehicle parked some distance away. As a result of this the transmitter produced a weak signal presumably due to being knocked off tune. It is planned to immobilize this animal again for retuning.

Since the beacon transmitter was not available when the work was commenced in November 1969, one of the animal transmitters was used instead. Placed on a broomstick in a tree 4 metres above the ground on a hill of about 100 metres height, if could be heard at fair strength over most of the study area and served to demonstrate the value of such a beacon. It also showed that when several hills obstruct the signal path thus effectively blocking the direct path, stronger signals can sometimes be received from hills lying to the left or the right of the direct path and serving as reflectors. In cases like these directional measurements may show large errors.

This beacon which could even be heard at the main camp – a 10 km line-of-sight path – has subsequently been augmented with the more powerful permanent beacon placed close to it on a hill rising about 200 metres above the surrounding terrain and favourably placed relative to the study area.

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By Fred Anderson and Peter Hitchins

ERRATA

It is regretted that some errors appear in this paper. Readers are requested to make the following corrections:

Page	Location of error:	Amend to read:
27	Section B, 2nd line: (1970)	(1971)
28	Right-hand column, 7th line: ...nil...	...nul...
28	Right-hand column, section A: ...1970)	...1971)
30	Legent to figure 4: 425 WG	42 SWG
31	Right-hand column, 2nd paragraph, 2nd line: ...gamma matchings...	...gamma-match...
32	Right-hand column: ...cable. They will...	...cable, they will...
32	Right-hand column, 4th paragraph: ...impedance of 72 x 36 = 51 ohms.	...impedance of $\sqrt{72 \times 36} = 51$ ohms.
32	Right-hand column under section (ii) Receiver: (1970)	(1971)
35	References - Anderson, F. and de Moor, P.P. (1970) etc.	Anderson, F. and de Moor, P.P. (1971). A system for radiotracking monkeys in dense bush and forest. J. Wildl.Mngmt. 35 : 636-643 (Oct. 1971)